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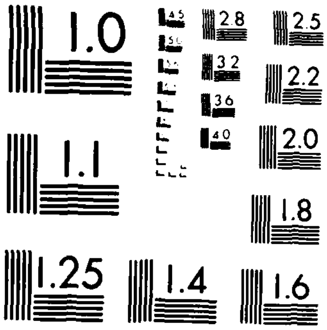

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

PRELIMINARY HELICOPTER DESIGN DECISION
MAKING BASED ON FLIGHT PERFORMANCE FACTORS

by

Patrick V. Adamcik

September 1984

Thesis Advisor: Donald M. Layton

Approved for public release: Distribution unlimited

REPORT DOCUMENTATION PAGE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This thesis will assists those evaluating helicopter design to make preliminary judgments about the feasibility of new designs. By using the computer program developed in this thesis, a designer can produce estimates for power requirements, endurance velocity, rate of climb, range velocity, hover ceiling, and service ceiling versus main rotor radius. These

20. continuation

estimates can also be examined for the effects of changes in main rotor radius, chord, and rotational velocity.

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Preliminary Helicopter Design Decision Making Based on Flight Performance Factors

by

Patrick V. Adamcik
Captain, United States Army
B.S., University of Texas at Austin, 1977

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

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ABSTRACT

This thesis will assist those evaluating helicopter design to make preliminary judgments about the feasibility of new designs. By using the computer program developed in this thesis, a designer can produce estimates for power requirements, endurance velocity, rate of climb, range velocity, hover ceiling, and service ceiling versus main rotor radius. These estimates can also be examined for the effects of changes in main rotor radius, chord, and rotational velocity.

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ACKNOWLEDGMENT

Acknowledgment is made of the assistance provided by Professor Donald M. Layton, thesis advisor , who helped in guiding the direction of this thesis. Much of the necessary information for this thesis was found during Professor Layton's exellent classes on performance and design of helicopters.

I. INTRODUCTION

A military engineering officer in a program or project office would probably never be called on to prepare a conceptual design of a helicopter, but he may well be required to evaluate a proposal submitted by a commercial contractor.

The requirement for such an evaluation might be stated as:

> Determine if this design meets or exceeds the performance factors listed on the next page and if the design can be changed to optimize the performance.

There are several approaches one could use to complete this task. One could use a hand held calculator and enter the data for the many equations, or one could write a program for a micro or main frame computer to produce the required information. Both these options are laborious and time-consuming. By choosing the first option, one may be able to complete the task in two or three weeks or if it is decided to write a program, one may finish in one week provided that there are no "bugs".

The best solution of course, is to use an existing program which can determine the necessary information for the specification parameters. In addition, this program should be able to show what happens if certain parameters are allowed to vary, thus providinq the formation for optimization.

The objective of this thesis was to develop such a program that will graphically represent power requirements, endurance velocity, rate of climb, range velocity, hover ceiling and service ceiling all as a function of main rotor radius for four different cases. The graphs that result from this program should enable one not only to evaluate the basic helicopter design, but also to make recommendations for design improvement.

II. APPROACH TO THE PROBLEM

Six performance factors (power requirements, endurance velocity, rate of climb, range velocity, hover ceiling and service ceiling) were determined to be major in designing of a helicopter. In order to obtain estimates for these, a Fortran program was to be written to be used with "DISSPLA" (Display Integrated Software System and Plotting Language).[Ref. 1], to plot the results of the performance factors versus main rotor radius on either a screen or as a hard copy from the main frame computer.

The equations required for calculating these factors were obtained from "Helicopter Performance",[Ref. 2], and "Helicopter Design Manual",[Ref. 3], both written by Donald M. Layton. These equations were examined and then grouped for the purpose of writing subroutines to ensure an effective use of computer time. The result was six subroutines, Sub-group A, [Appendix B], are used in all the performance calculations. Sub-group A consist of:

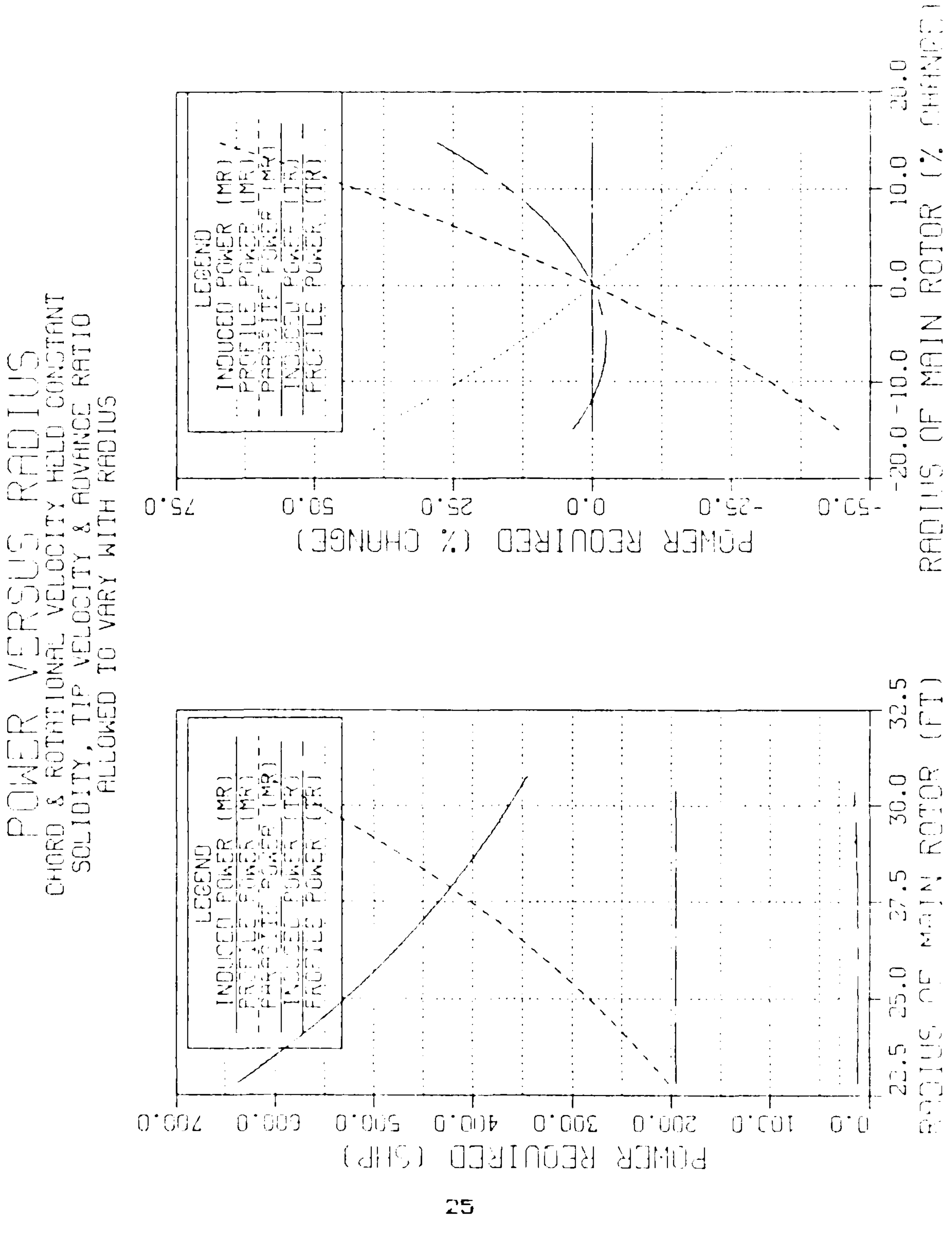
1. RHO - Calculates density from pressure altitude and temperature or given density altitude. Also determines pressure and temperature ratio for altitude versus sea level.

2. VELMR - Calculates induced velocity for main rotor.

3. VELTR - Calculates induced velocity for tail rotor.

APPENDIX A

COMPUTER PROGRAM OUTPUT - PLOTS



V. CONCLUSIONS

The objective of this thesis to design a program that evaluates a given set of helicopter design values was accomplished. The program will generate thirty two (32) graphs of six (6) performance factors for any single-mast helicopter. The program does allow for one to optimize a design through the evaluation of the variation of parameters for each performance factor.

At this point, the program takes into account neither compressibility nor blade stall. These factors would improve the estimations and may prove to be a worthwhile project for further work. Other points which could be examined are twin-blade and no-tail-rotor helicopters. Of the points mentioned above, blade design would probably be of most importance since little has been done to examine the optimization of blade twist and composite structure of blades.

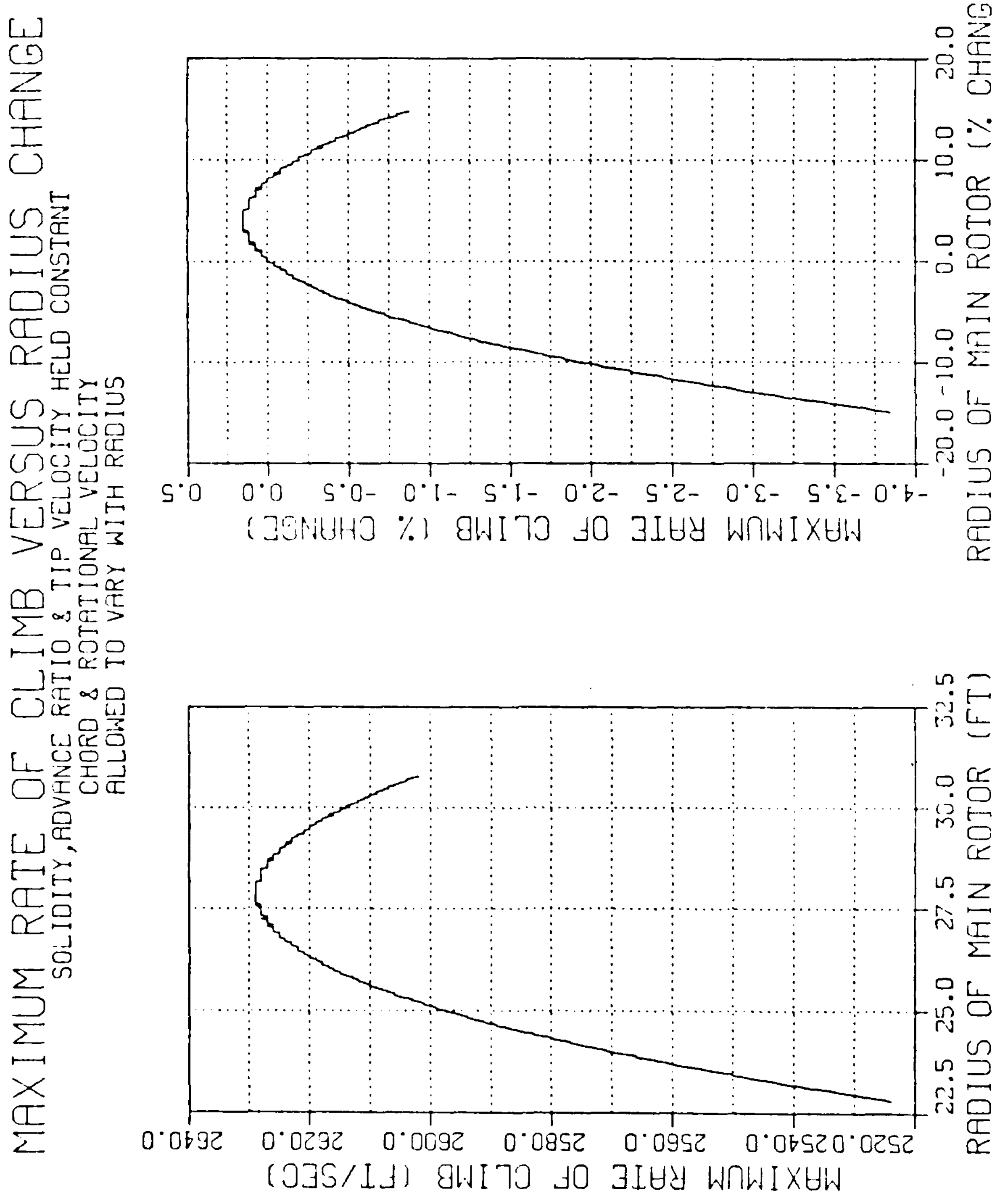


Figure 4.4 Example Maximum Rate of Climb - Case 4

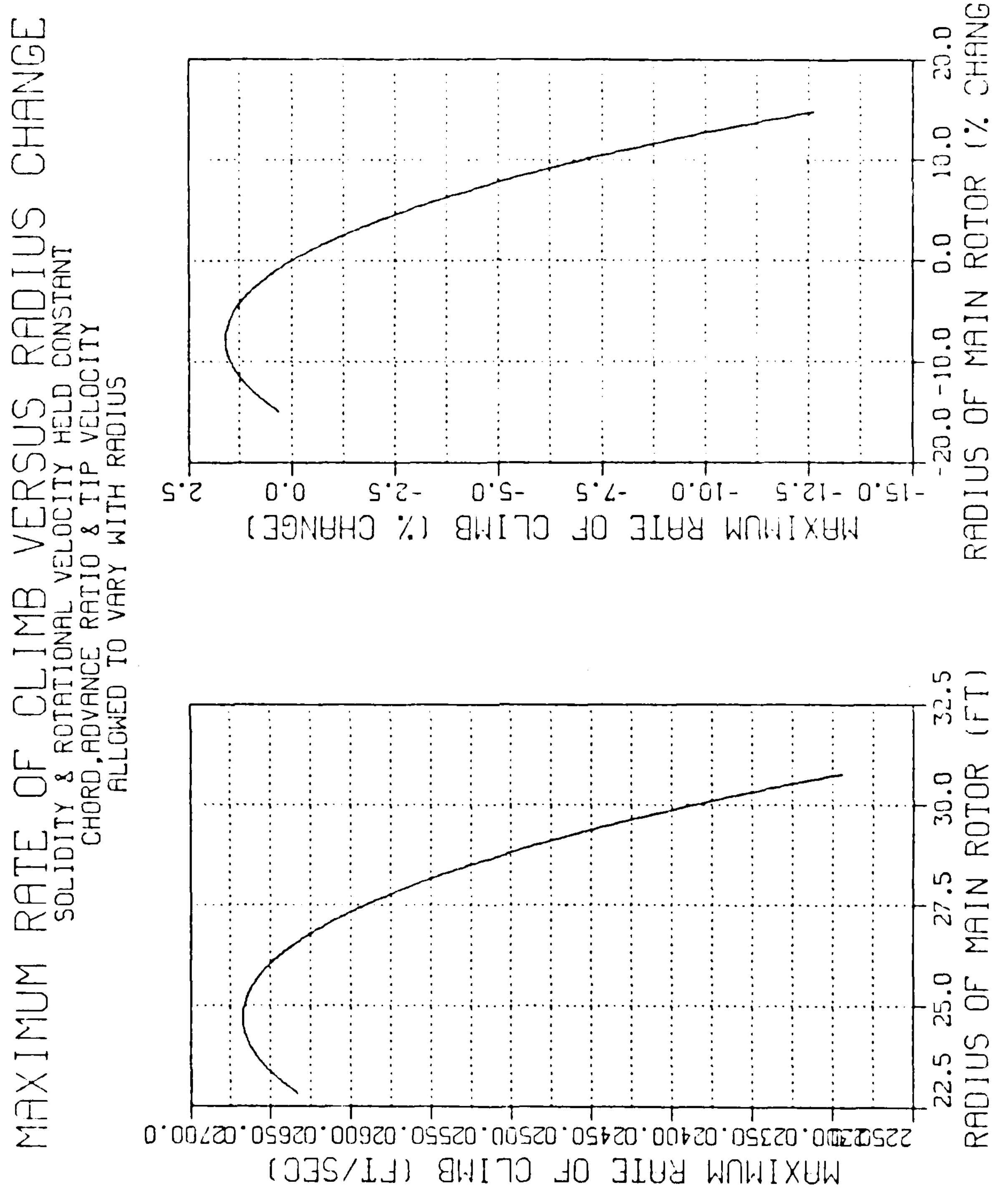


Figure 4.3 Example Maximum Rate of Climb - Case 3

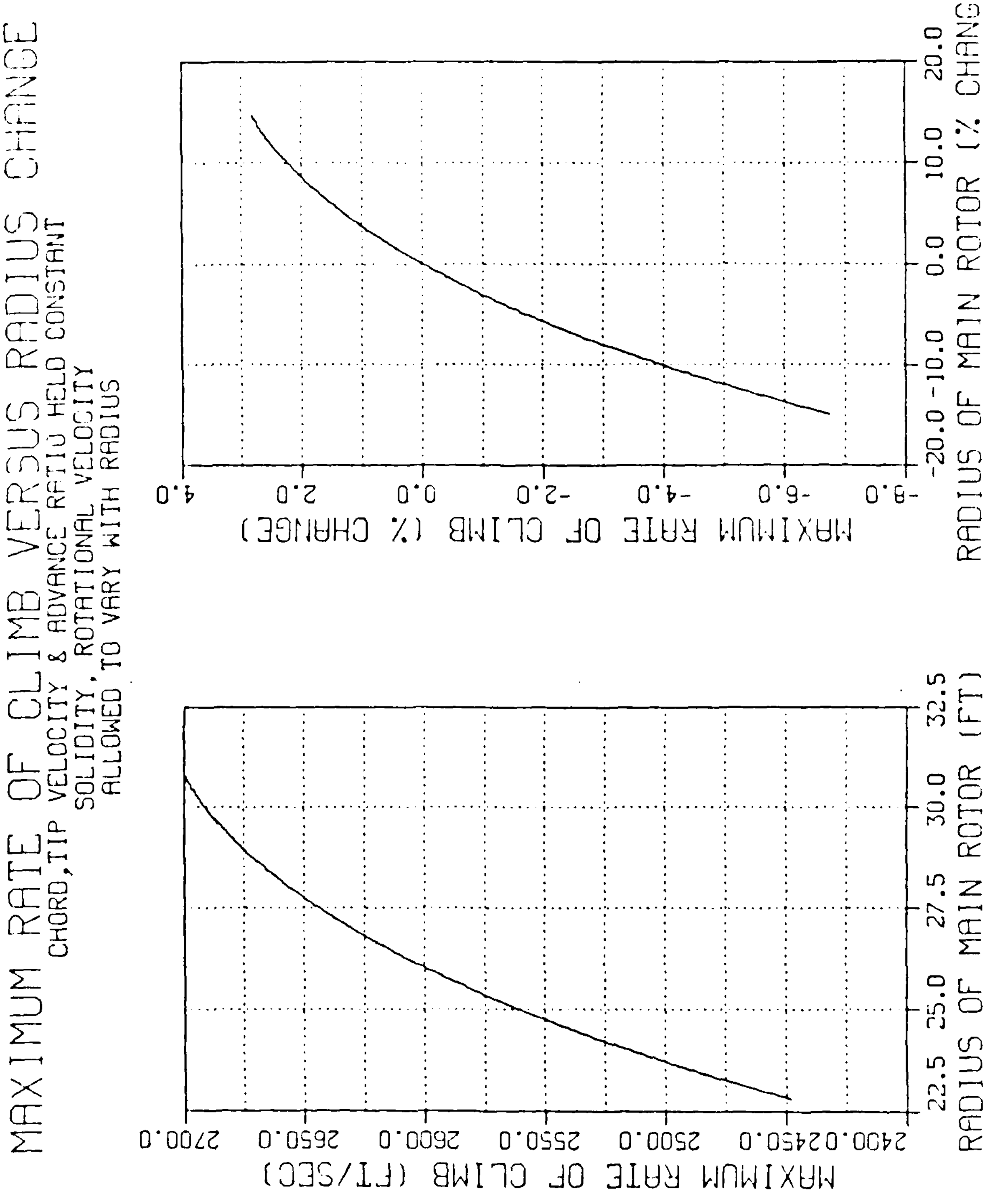


Figure 4.2 Example Maximum Rate of Climb - Case 2

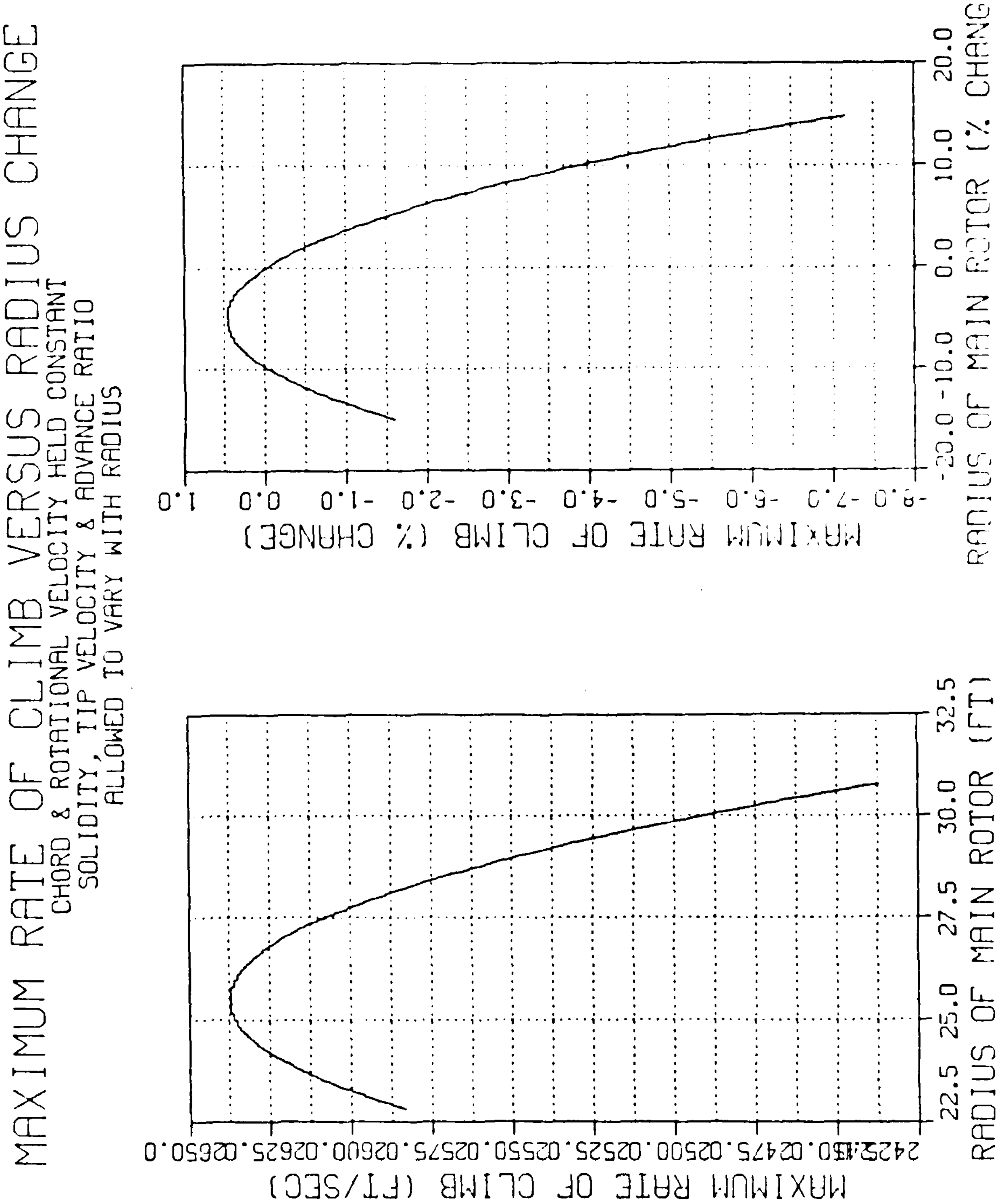


Figure 4.1 Example Maximum Rate of Climb - Case 1

and percent increase of rate of climb. The cases were explained in Table 3 and the Figures follow Table 4.

Table 4

Case Evaluation of Maximum Rate of Climb Plots

Case	Figure Reference	Rate of Climb(ft/sec)	Radius (ft)	Percent Increase
1	4.1	2628	27.8	+ 0.130
2	4.2	2668	24.8	- 0.156
3	4.3	2700	30.63	+ 2.80
4	4.4	2637	25.63	- 5.00

From examining Table 4, it would be best to increase the radius to 30.63 feet while holding the chord to 1.75 feet. the tip velocity to 723.6 ft/sec (radius times rotational velocity), changing the rotational velocity to 23.62 rad/sec, and calculating solidity from radius and chord. This, however, may not be the best answer if there is a limitation to the radius of the blade. For this particular example, the optimum solution may be to leave the design as it is. Increasing or decreasing the radius by small amounts does little to increase or decrease the rate of climb.

One must not only look at one factor in making the final decision. The changes affect the performance factors in different ways, therefore, the final decision must be made after weighting all the changes against all the performance factors.

IV. RESULTS

The program will generate a total of thirty two (32) plots. The first twelve (12) pertain to power requirements. This includes induced, profile, and parasite power for the main rotor; and induced and profile power for the tail rotor. To indicate a relation between the power terms of the main rotor the figure of merit (induced divided by the sum of the induced and profile power) is included. The sum of the terms (total power) for the main and tail rotor was included with the total power required for the aircraft. The remaining twenty (20) plots are for the performance factors of endurance velocity, rate of climb, range velocity, hover ceiling and service ceiling.

The data for this particular model (UH-60A) was used to illustrate the features of the program and the results presented are typical for this example only. The specifications of any model or design can be used as long as the assumption of a single-mast helicopter with rectangular blades is followed.

The plots created by the program represent the results of varying the main rotor radius, chord or rotational velocity. To example how to interrupt the results, the four (4) plots for Maximum Rate of Climb will be analyzed. Table 4 compares the results in relation to rate of climb, radius

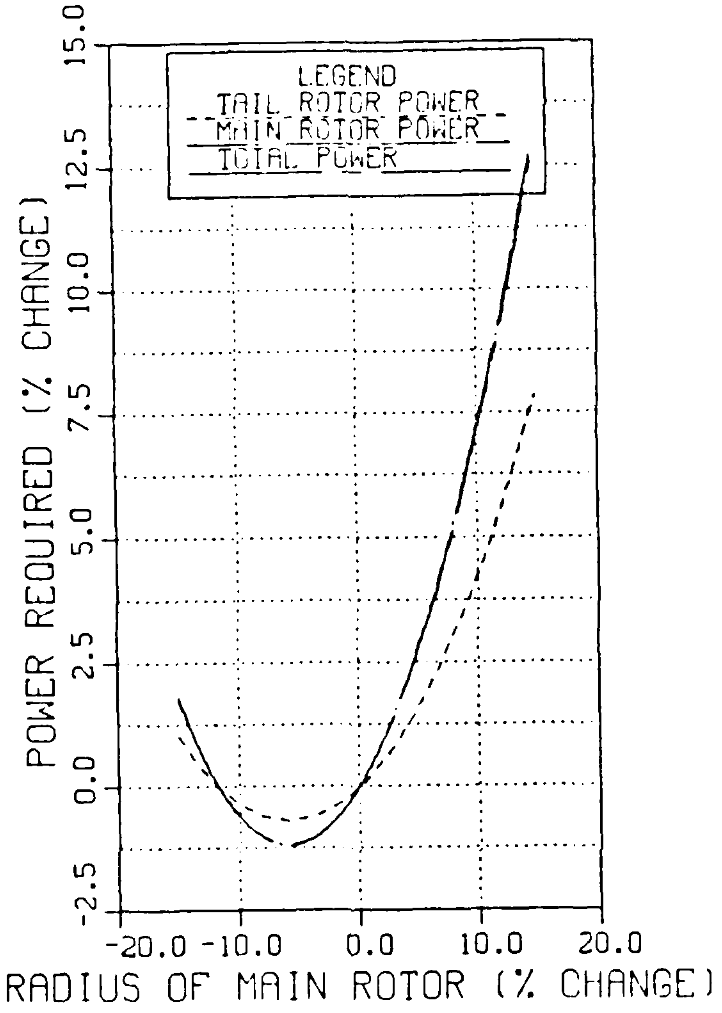


Figure 3.2 Example of Right Hand Plot

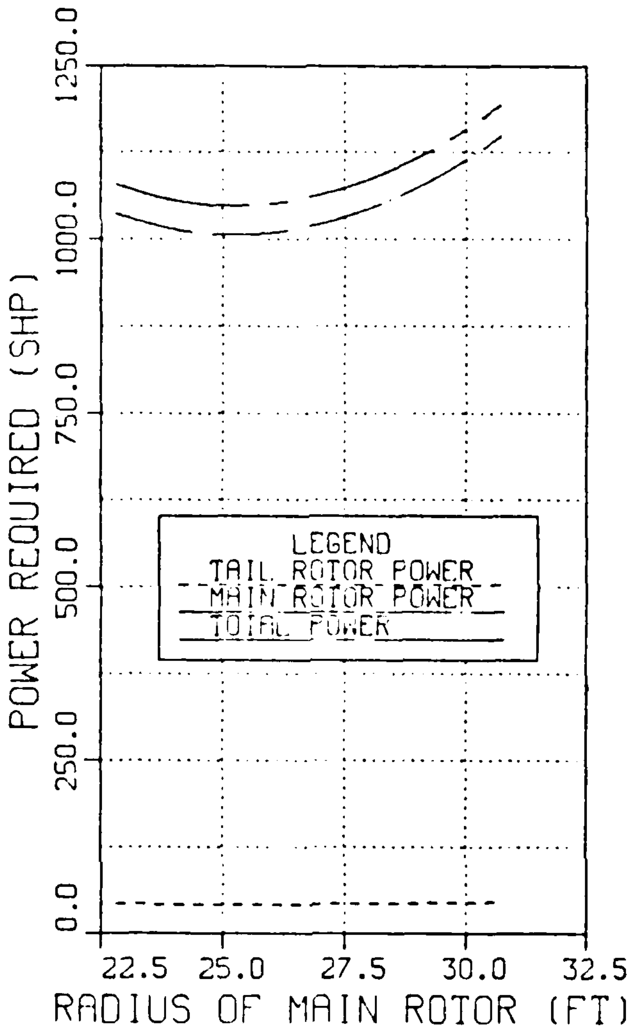


Figure 3.1 Example of Left Hand Plot

The right hand plot shows the values of the performance factors based on a percent difference from the value at the specification conditions versus a percent difference of the radius from the radius specification. Figure 3.2 shows an example of power required (% change) versus radius of the main rotor (% change), Case 1.

percent (5%) for transmission losses (if three engines are used, an additional transmission is required), [Ref. 2].

The secondary goal of the thesis was to examine four (4) different cases involving main rotor Radius, Chord, Rotational Velocity, Tip Velocity, Advance Ratio, and Solidity. Table 3 shows how these variables were used in each of the four (4) cases.

Table 3

Case Use of Variables

	Radius	Chord	Rotational Velocity	Advance Ratio	Tip Velocity	Soliditv
Case 1	V	C	C	V	V	V
Case 2	V	C	V	C	C	V
Case 3	V	V	C	V	V	C
Case 4	V	V	V	C	C	C

V : VARIES C : HELD CONSTANT

Advance Ratio, Tip Velocity, and Solidity when held constant keep their values at the specification conditions. The values of Chord and Rotational Velocity were allowed to vary when Advance Ratio, Tip Velocity, or Solidity were held constant as shown in Table 3.

The graphs consist of two (2) plots representing the same data but presented in different ways. The left hand plot shows the actual performance factor value versus main rotor radius. Figure 3.1 shows an example using power required versus main rotor radius, Case 1.

The example uses a value of four (4.0) feet. This value is assigned to a variable called "diff". The program was written to allow the X-axis scale of the plot to be adjusted in accordance with any value you might choose for "diff". The Y-axis scales can also change based on the maximum and minimum values for the performance factor being considered.

Certain assumptions had to be made in order to write the program. Table 2 lists these assumptions and factors used and the line number in the program where the factors can be changed if needed.

Table 2

Assumptions Made in the Program

Assumption	Factor	Line Number
Single Mast Helicopters	NA	NA
Only Rectangular Blades	NA	NA
Profile Power Factor	4.3	1079,1106
Ground Effect Factor	1.6	1138
Transmission & Accessory Losses		
1 engine	SHP = (# ENG*ESHP-10.0)*0.97	560,780,887
2 engines	SHP = (# ENG*ESHP-10.0)*0.9*0.97	561,781.888
3 engines	SHP = (# ENG*ESHP-10.0)*0.9*0.94	562,782.889

ENG: Engine, ESHP: Engine shaft horsepower,
SHP: Rotor Shaft horsepower

The Transmission and Accessory Losses were calculated based on a loss of ten (10) horsepower for the accessories, ten percent (10%) for multiple engine installation, and three

III. SOLUTION TO THE PROBLEM

The program requires input data prior to compiling and execution. To demonstrate how to use the program a set of sample data was used. Table 1 is a listing of the required input data for the program.

Table 1

Sample Data for Use in Program

	Main Rotor	Tail Rotor
Radius	26.8 ft	5.5 ft
Chord	1.75 ft	0.81 ft
Rotational velocity	27.0 rad/sec	124.6 rad/sec
Coefficient of drag	0.008	0.008
Number of blades	4	4

General Helicopter Data

Weight	20000.0 lbs
Tail boom length	31.5 ft
Effective flat plate area (forward)	25.7 sq ft
Effective flat plate area (vertical)	31.8 sq ft
Main rotor height above skids or wheels	11.2 ft
Aircraft velocity (power calculations only)	90.0 kts
Plus/minus (+/-) value for main rotor radius	4.0 ft

Engine Data

Number of engines	2
Shaft horsepower output (military)	1561.0 shp
Shaft horsepower output (normal)	1318.0 shp
Shaft horsepower output (cruise)	989.0 shp
Specific fuel consumption (military)	0.46 lbs/shp/hr
Specific fuel consumption (normal)	0.47 lbs/shp/hr
Specific fuel consumption (cruise)	0.51 lbs/shp/hr

As indicated in Table 1, a value is inputted for the range over which you wish to examine the main rotor radius.

4. POWMR - Calculates power requirements for main rotor only.

5. POWTR - Calculates power requirements for tail rotor and total aircraft.

6. CONST - Calculates general constants to be used in the first five subroutines listed above.

In addition to the subroutines listed above, six more, Sub-group B, [Appendix B], were written to perform the necessary iterations to calculate the performance factors. Some of Sub-group B subroutines were iterated in steps (1000,100,10,1) so that it would not require extensive computer time to obtain the desired results. A final eight subroutines, Sub-group C, [Appendix B], were written to plot the results using DISSPLA.

The program takes into account neither compressibility nor blade stall. These considerations were omitted since this program was aimed at facilitating preliminary decision making for a new design, rather than a final production design, and usually the blade selected for a new design is taken from an existing helicopter.

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ALLOWED TO VARY WITH RADIUS

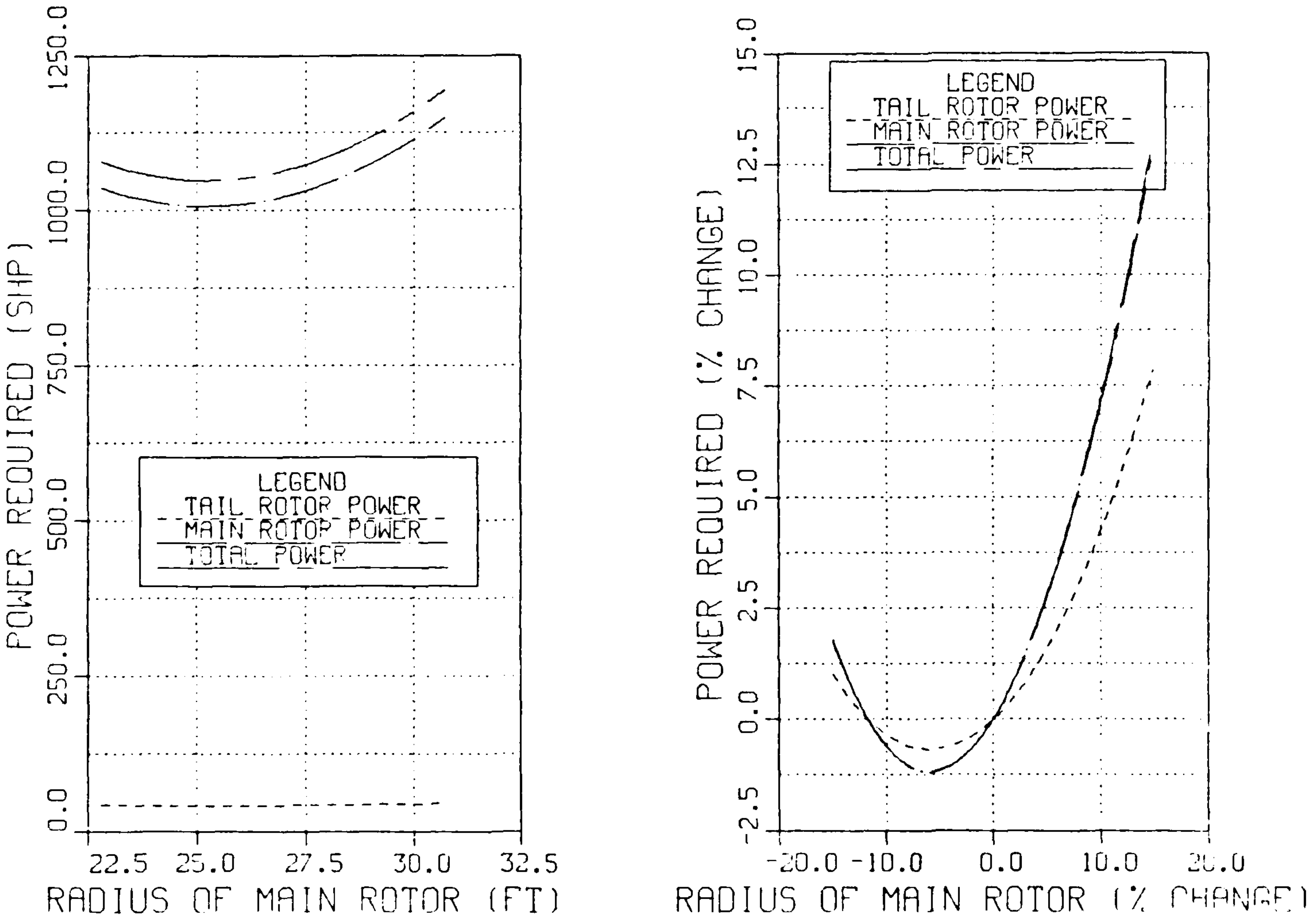

FIGURE OF MERIT VERSUS RADIUS CHANGE
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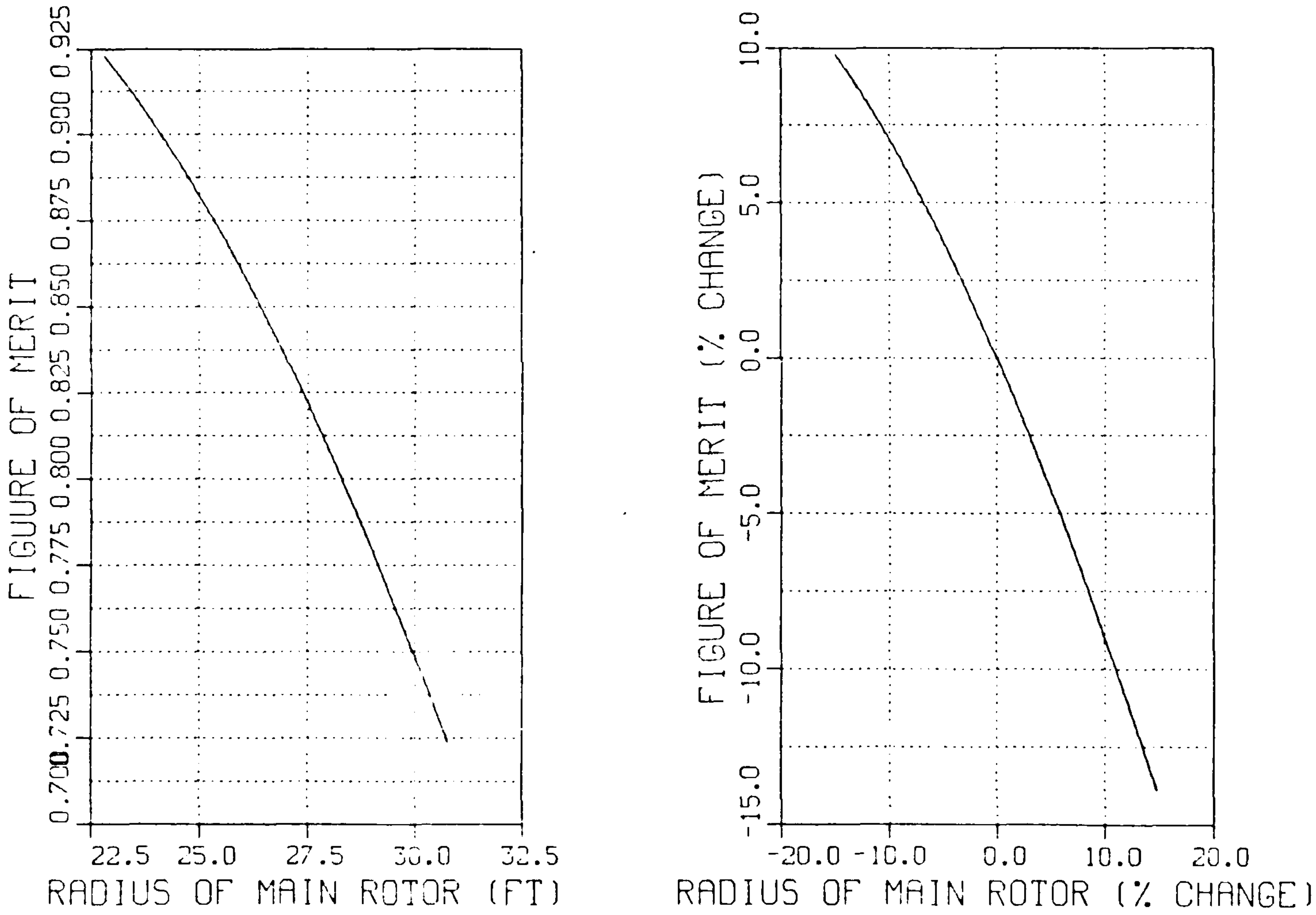

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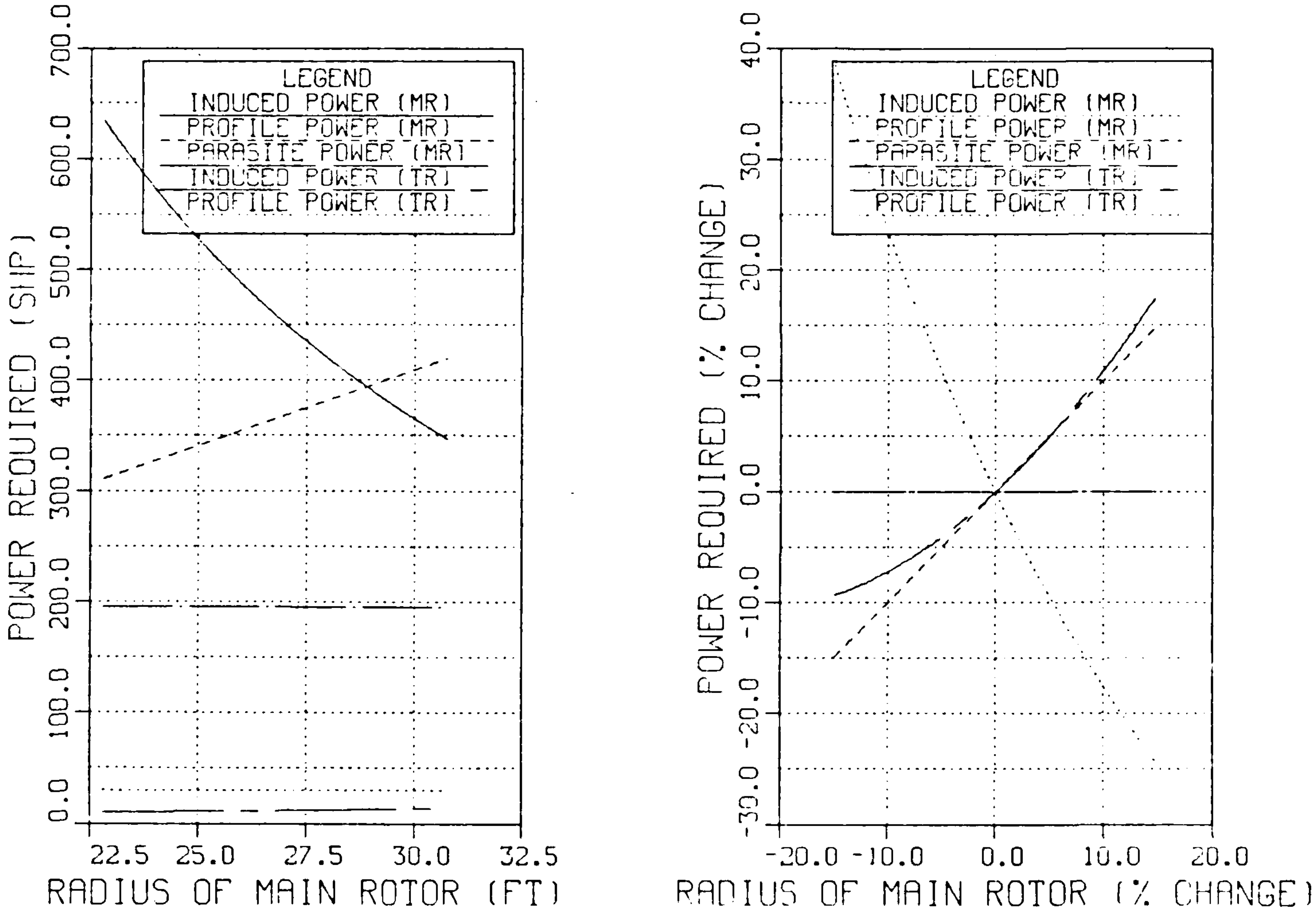

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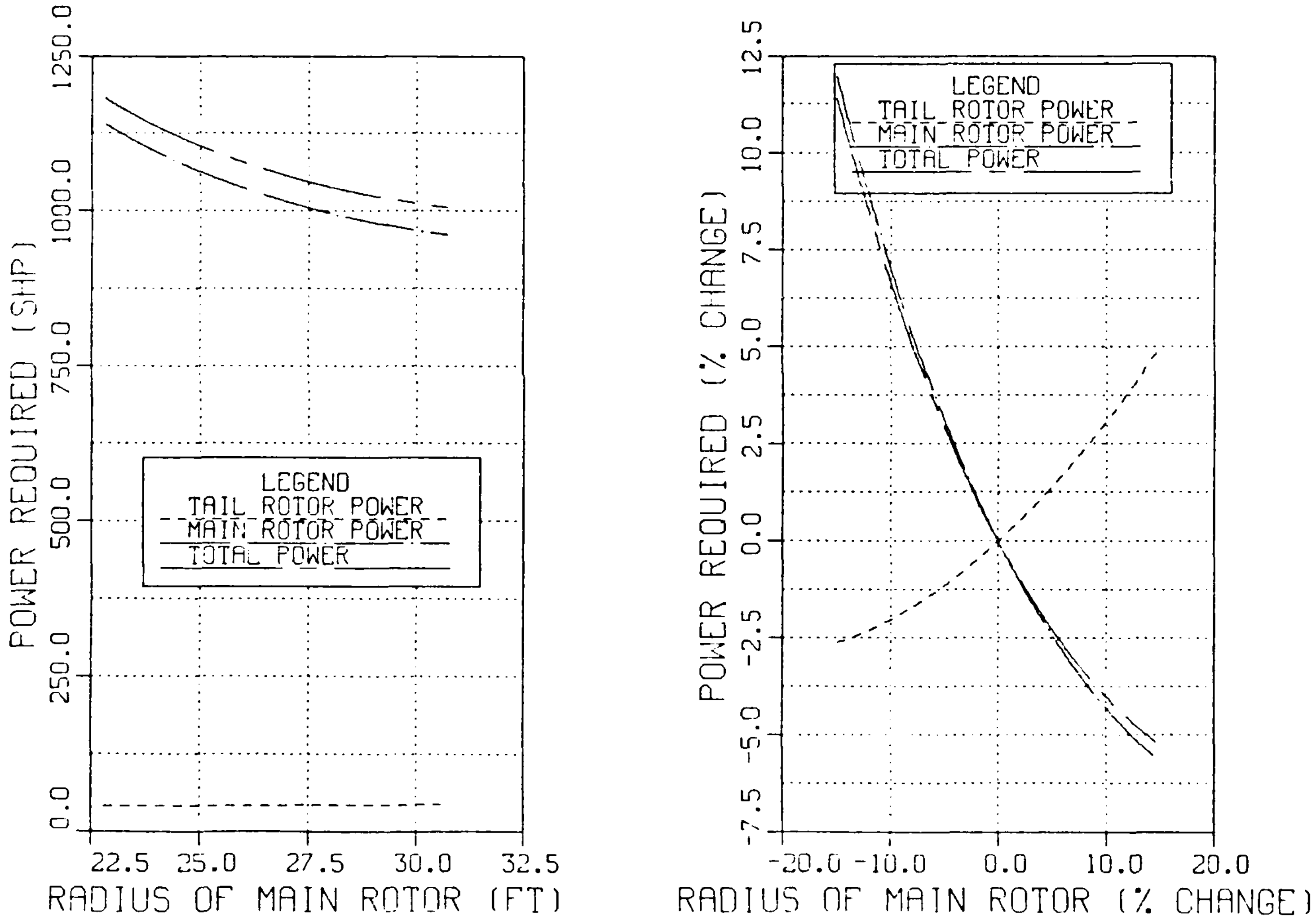

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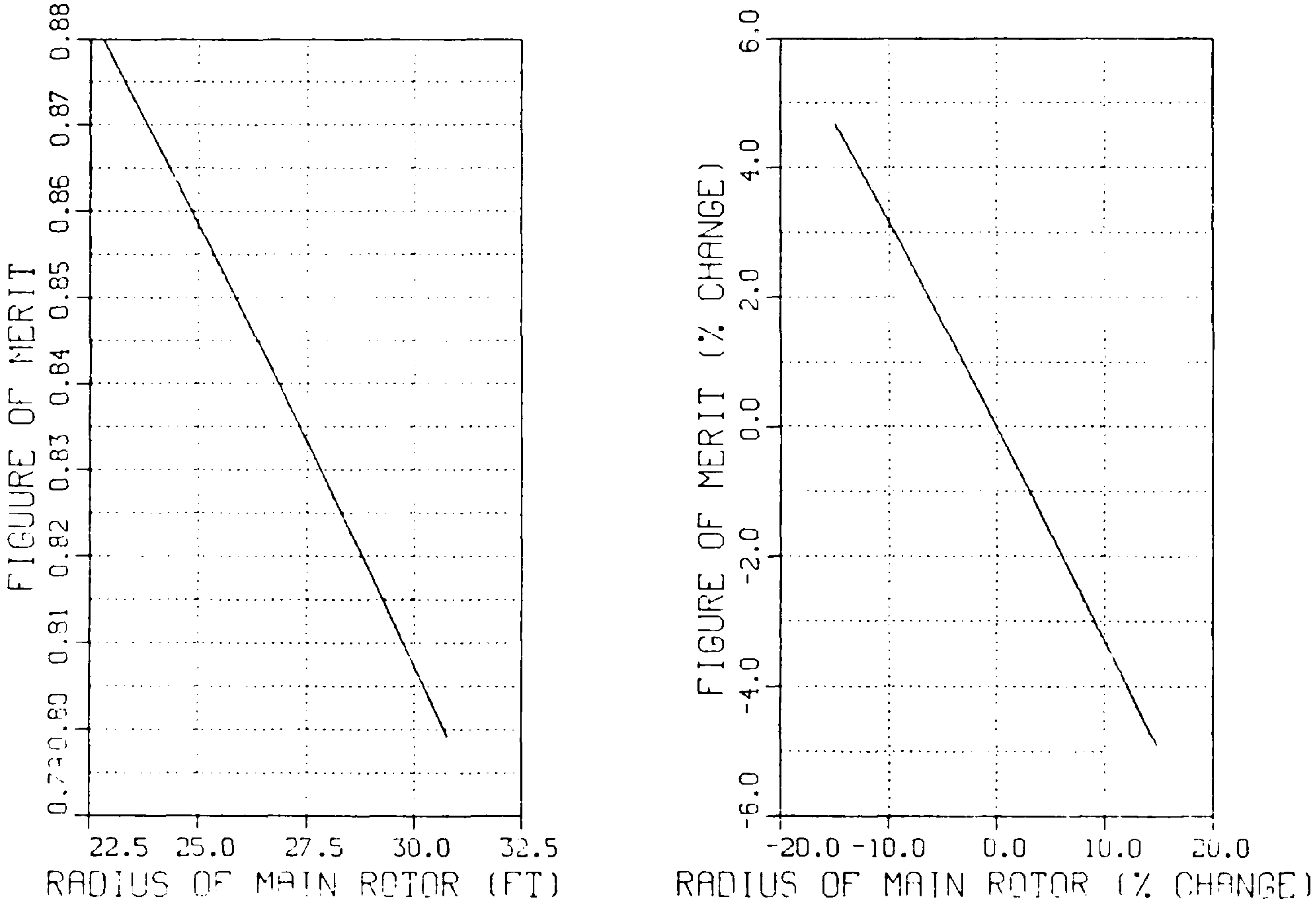

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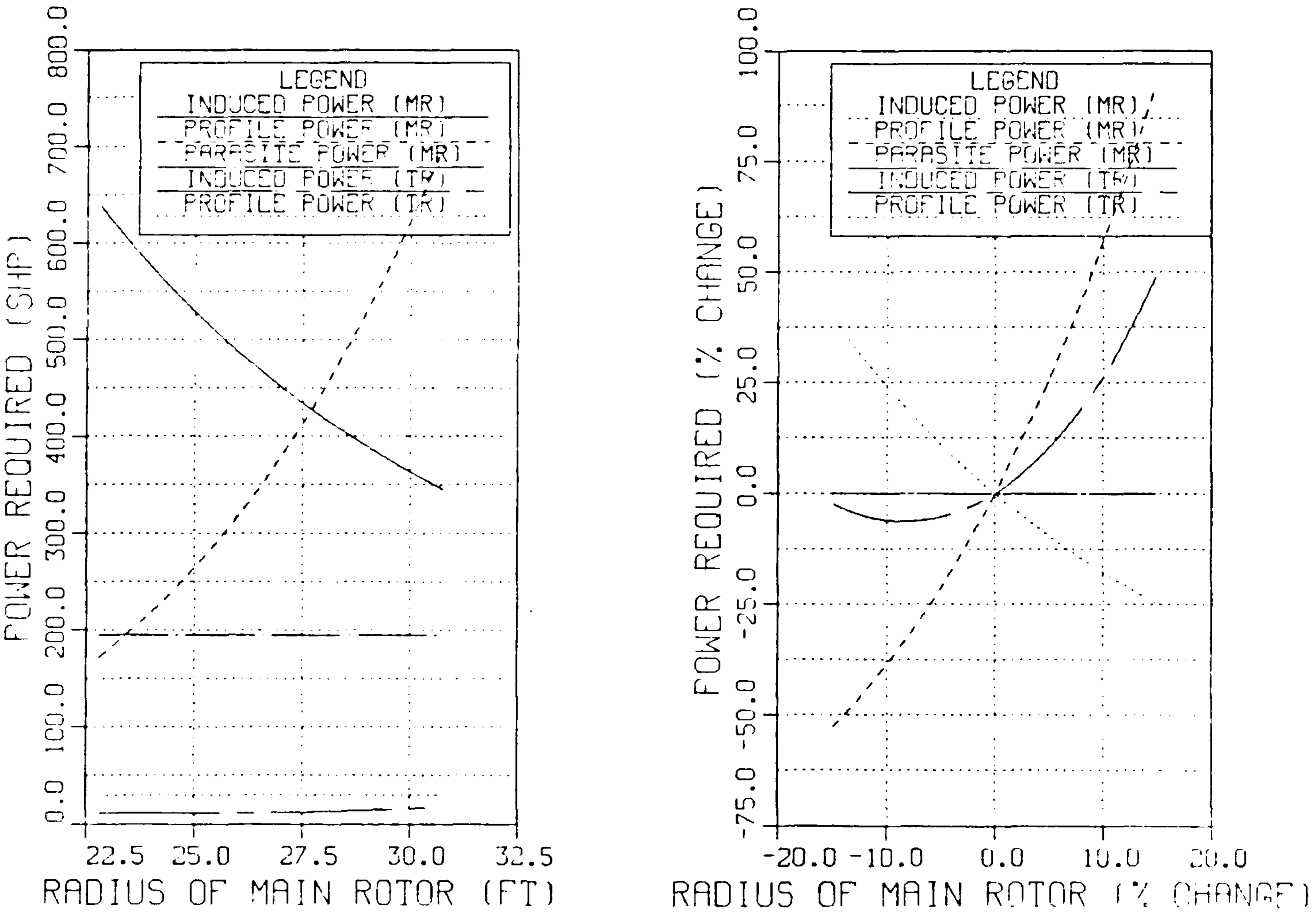

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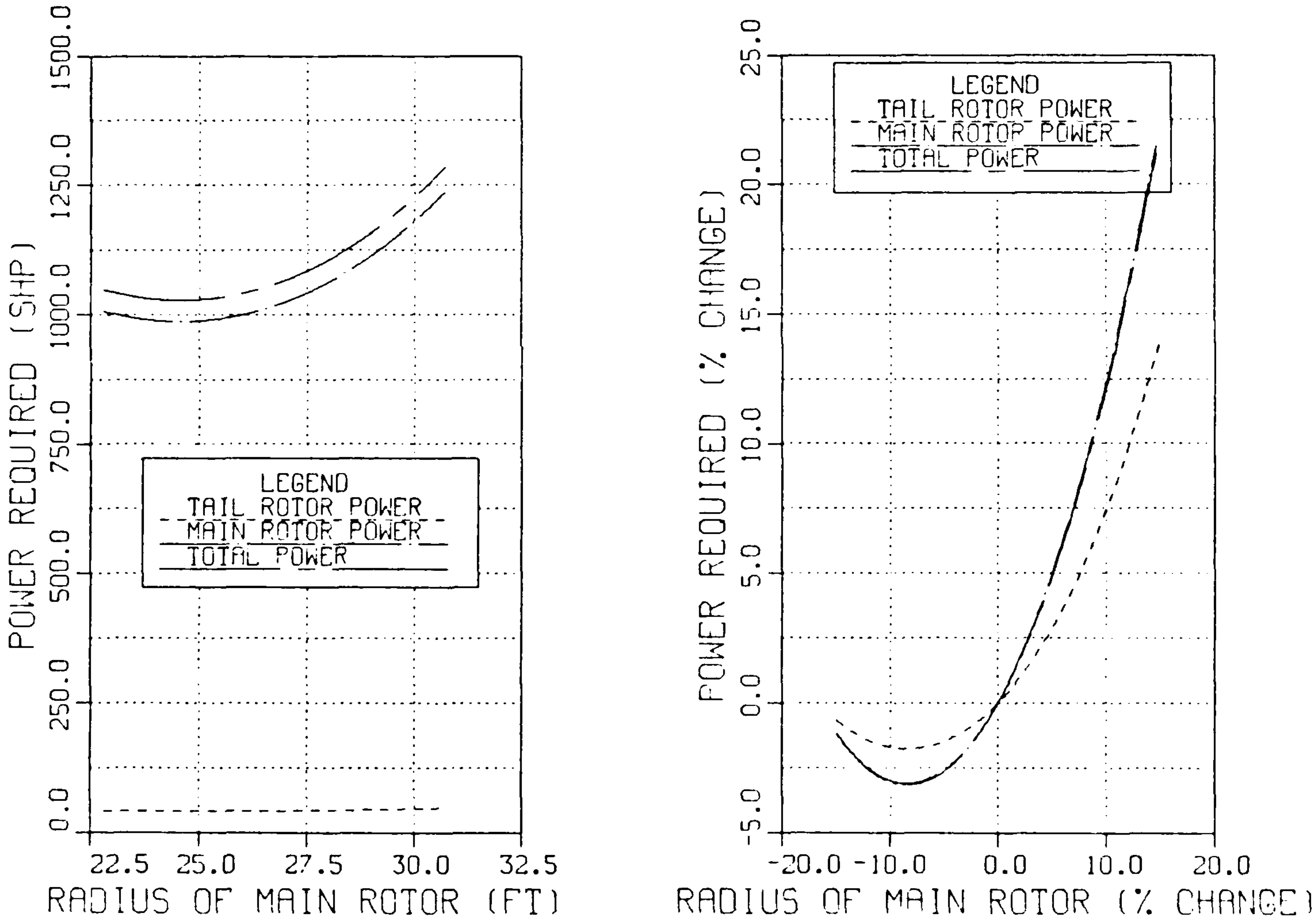

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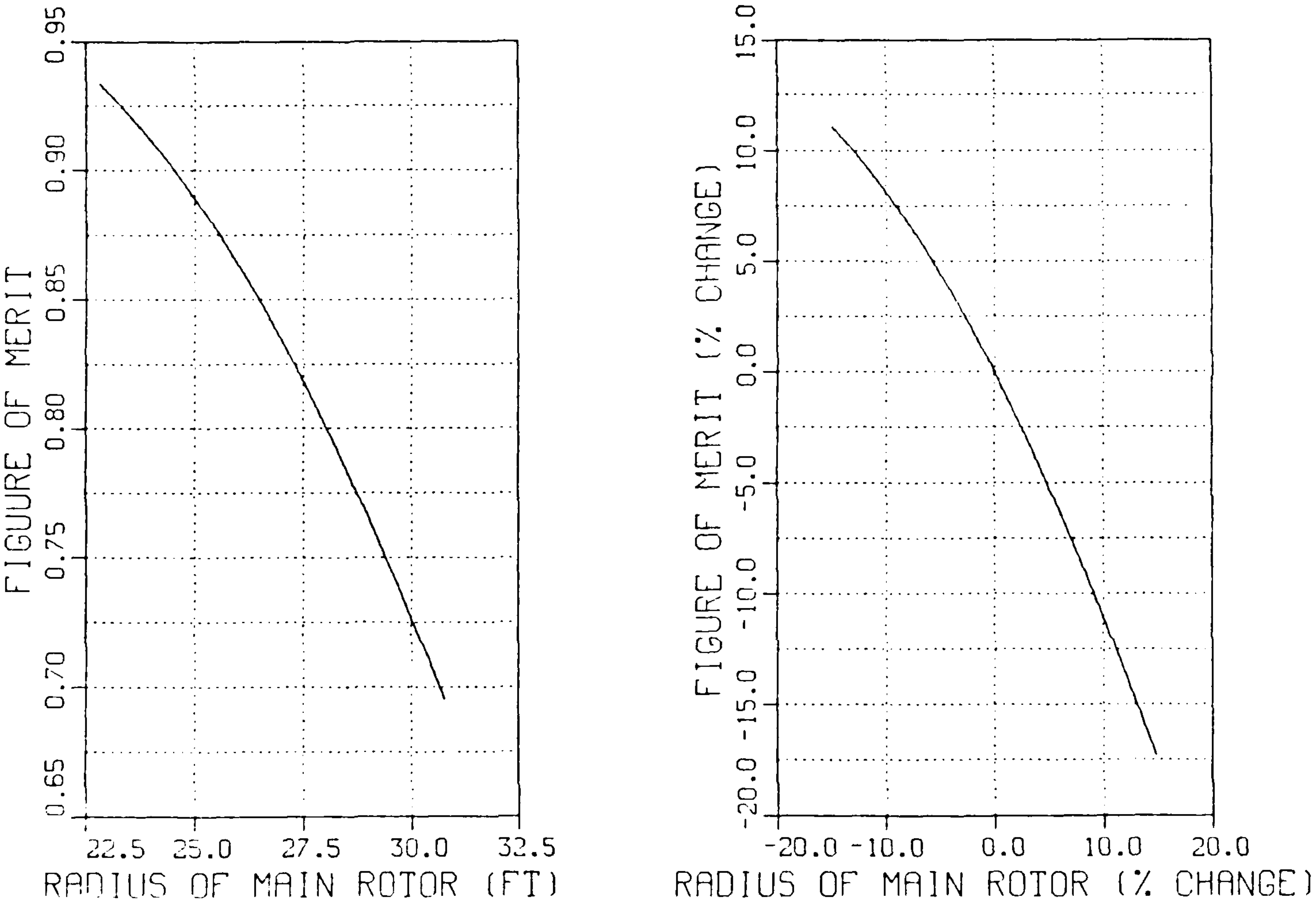

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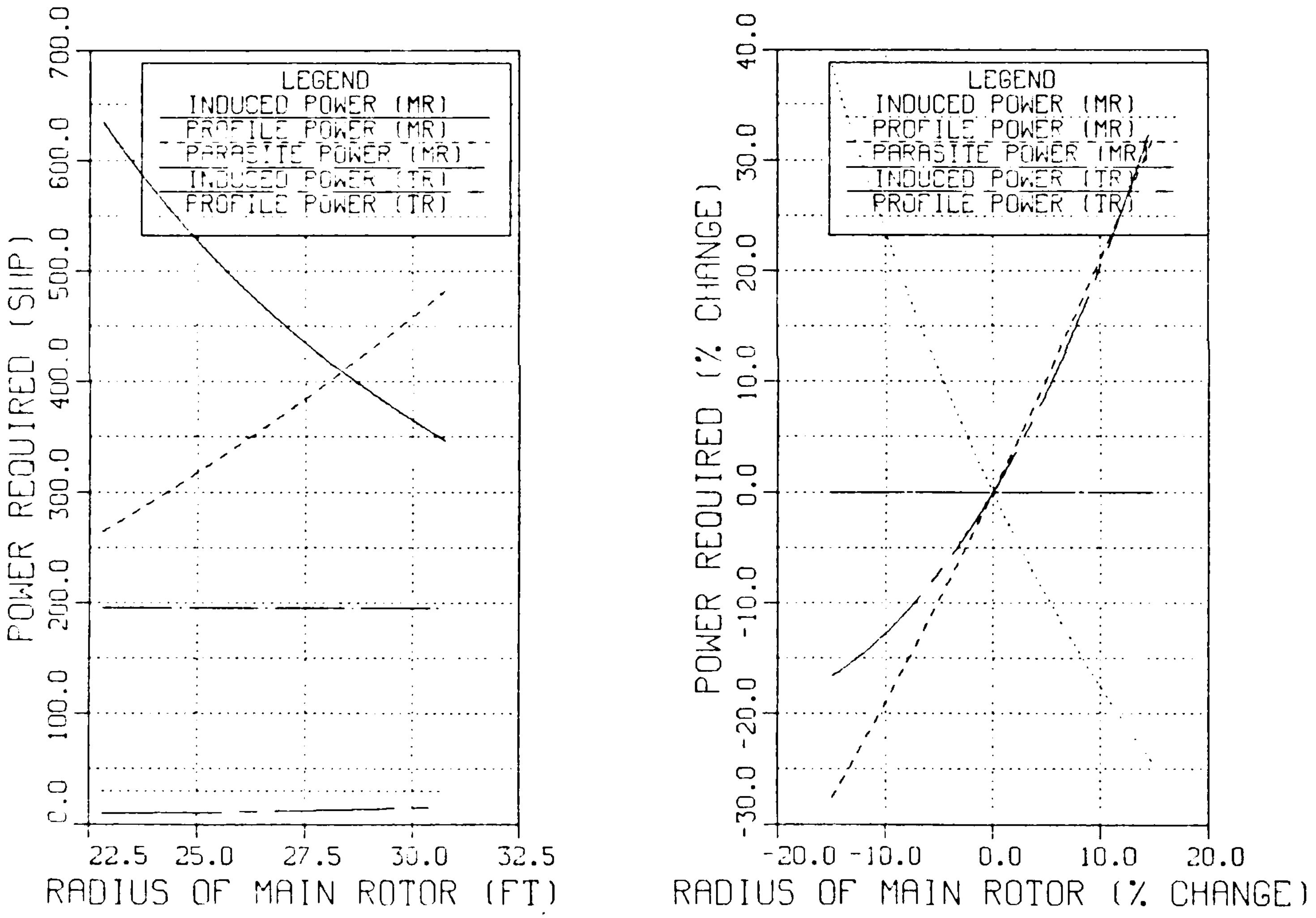

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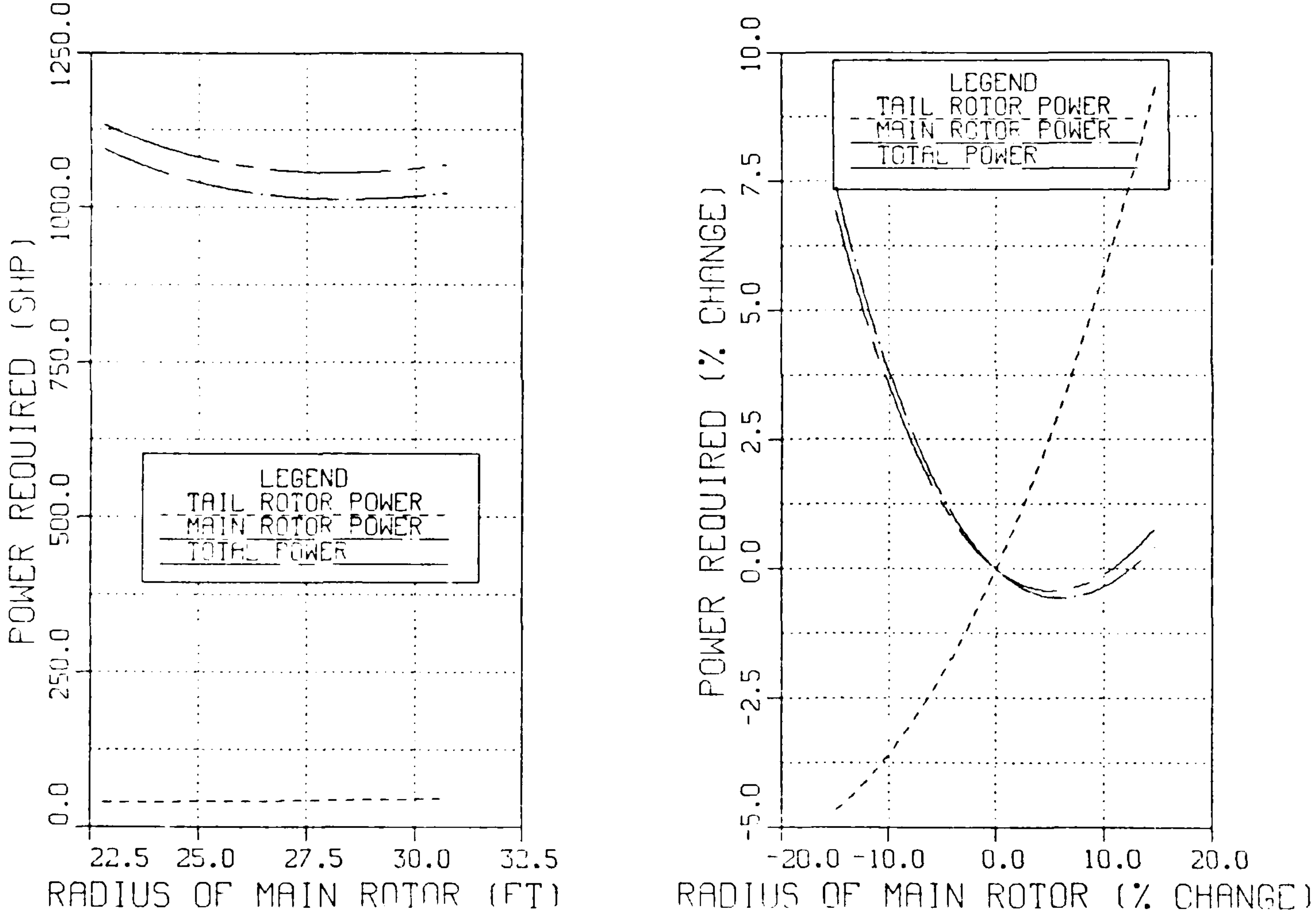

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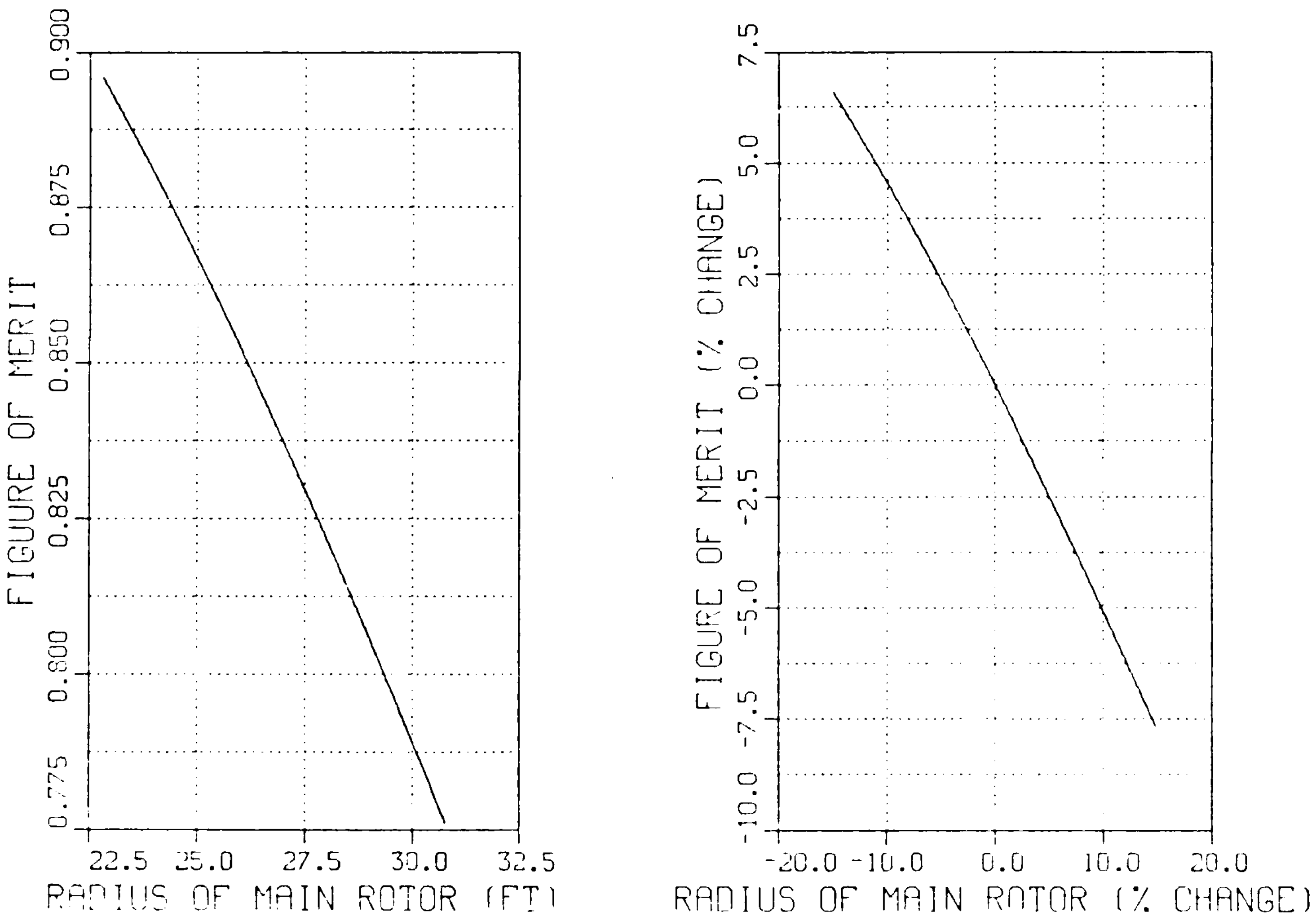

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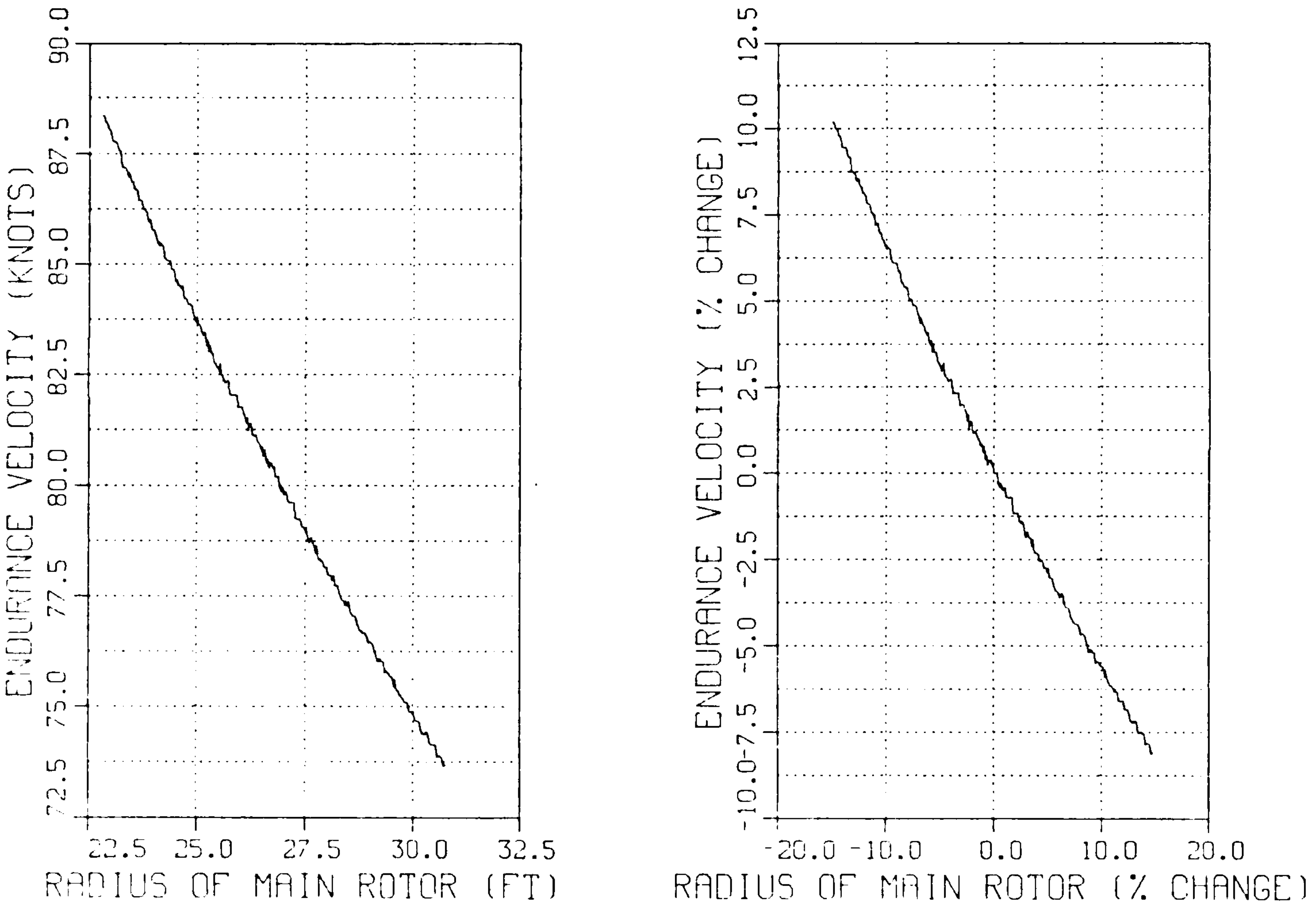

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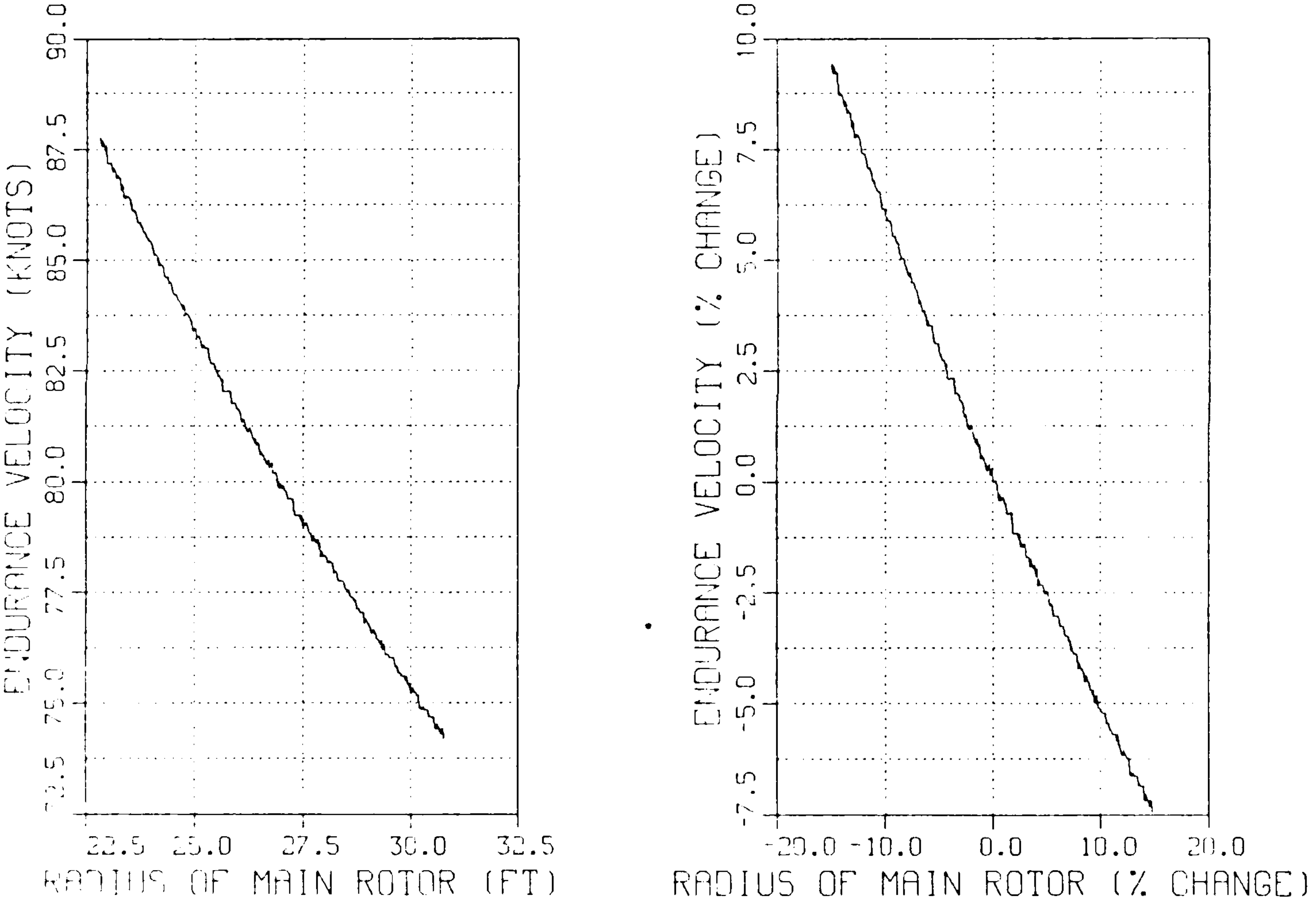

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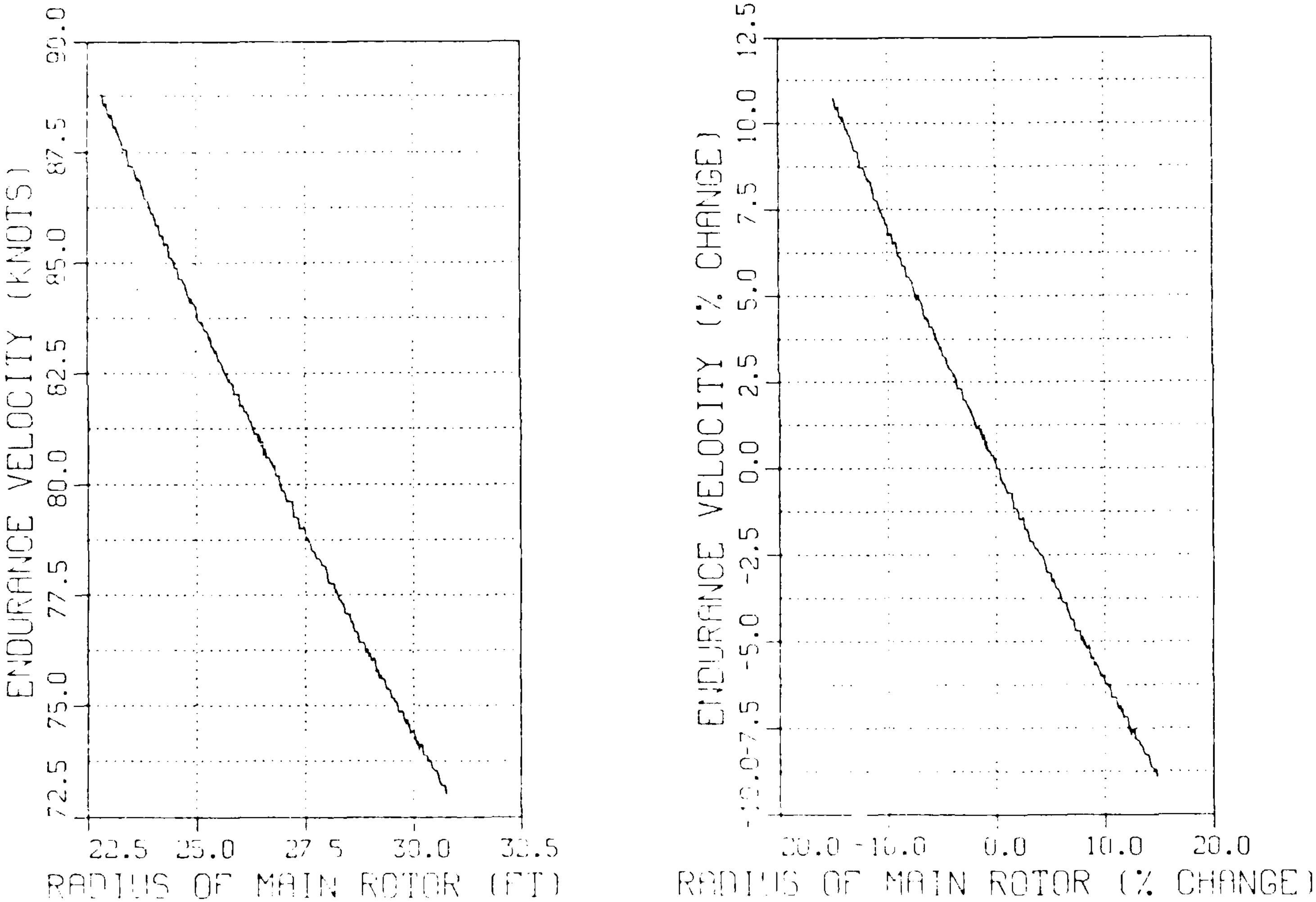

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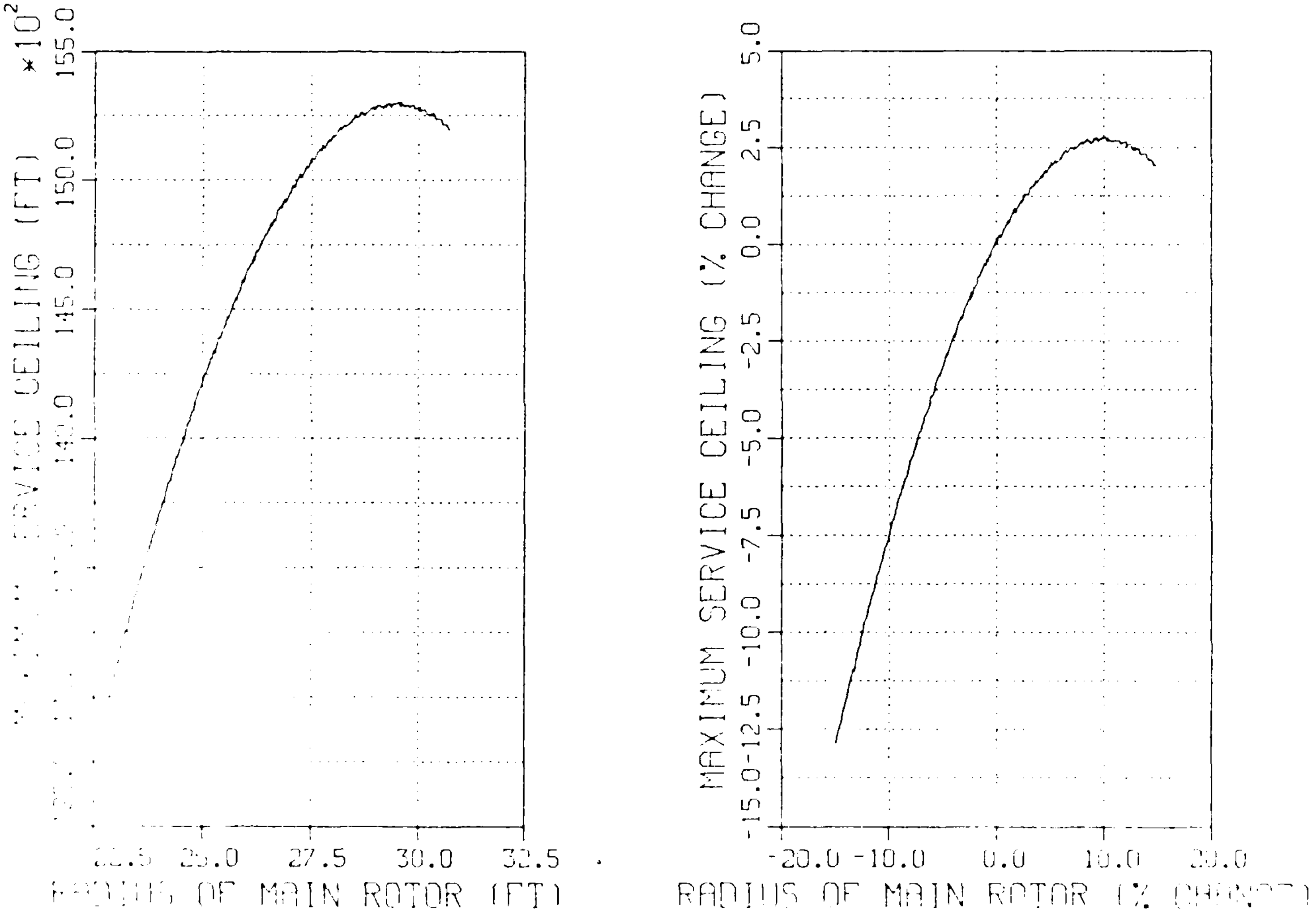

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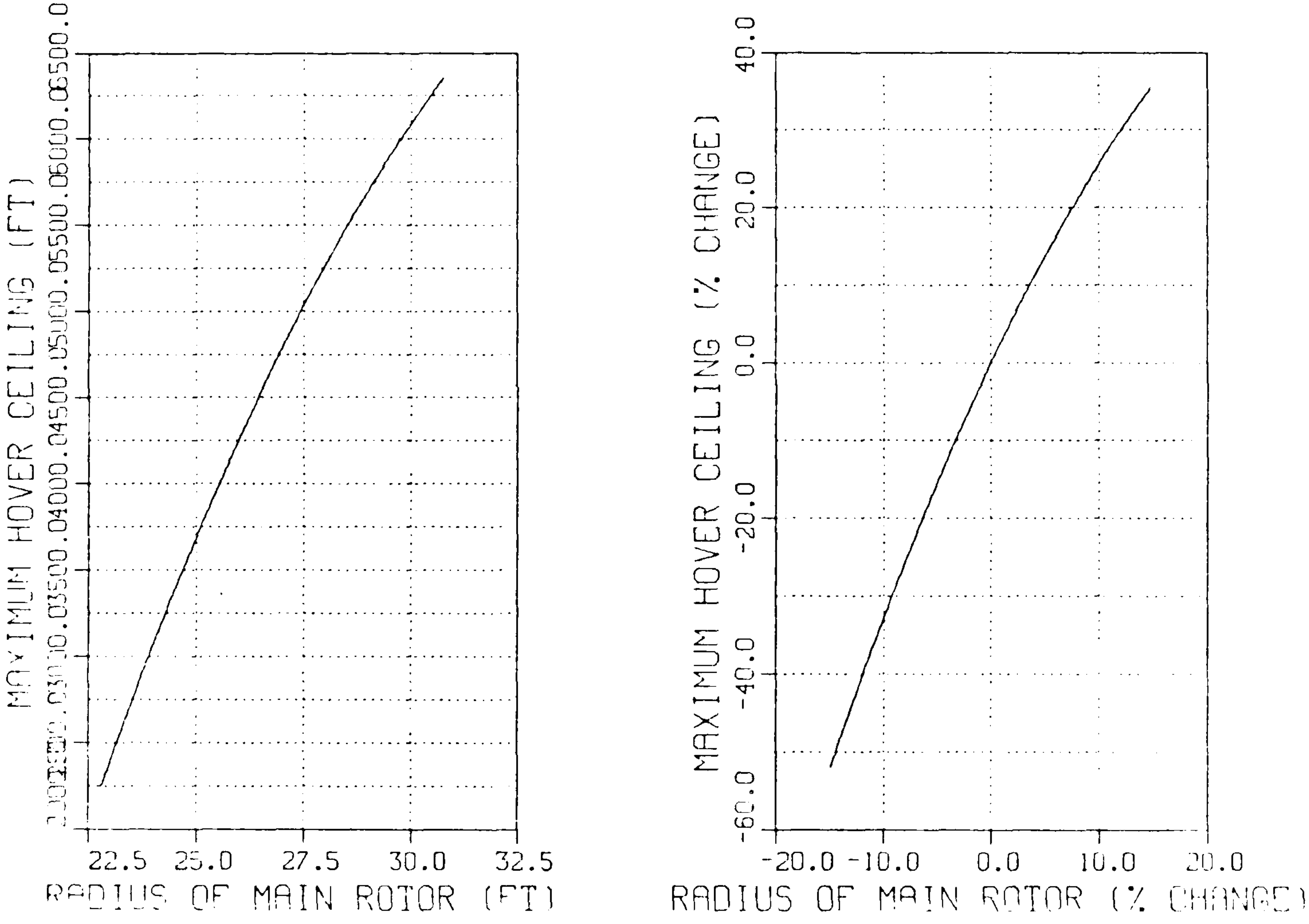

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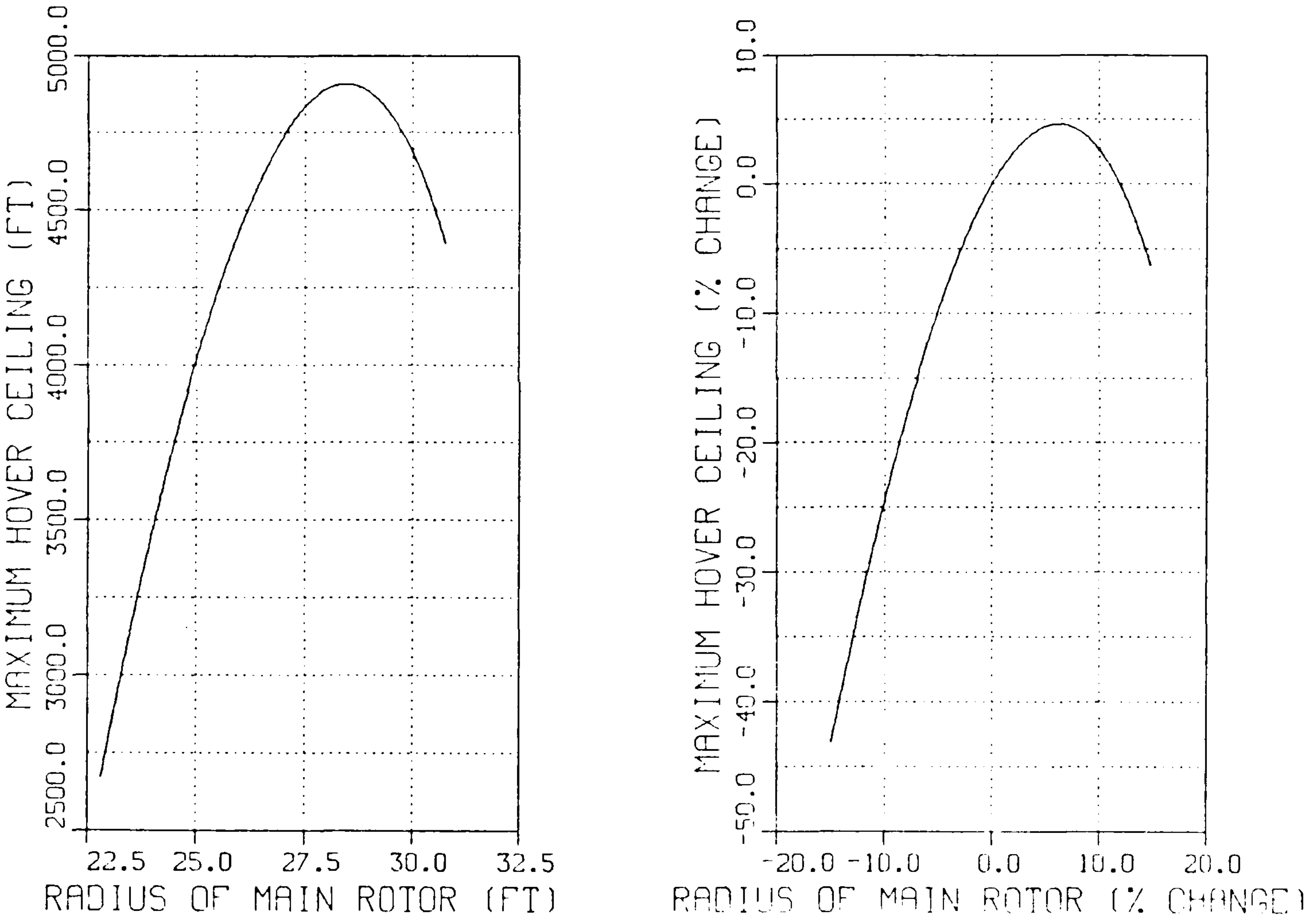

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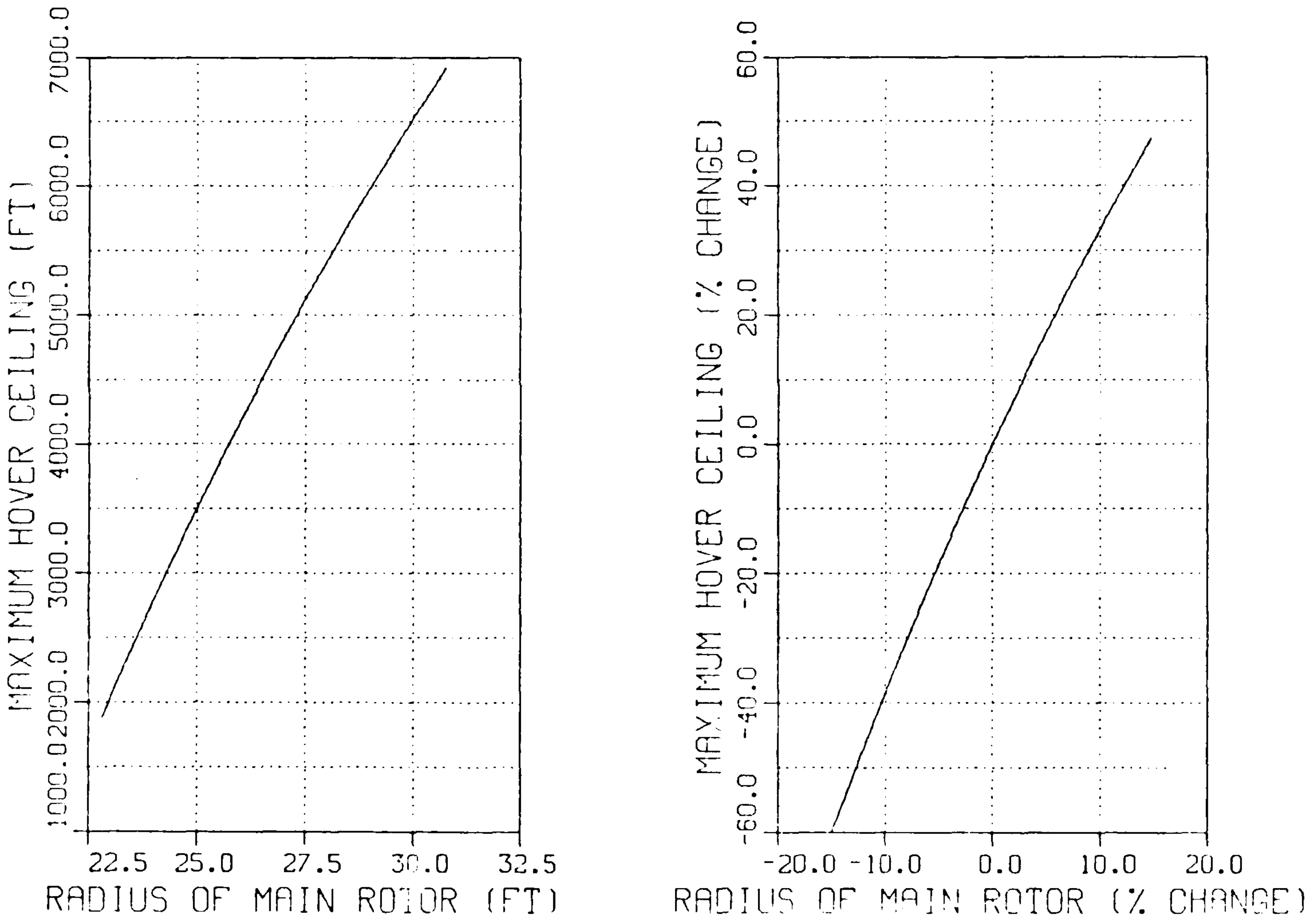

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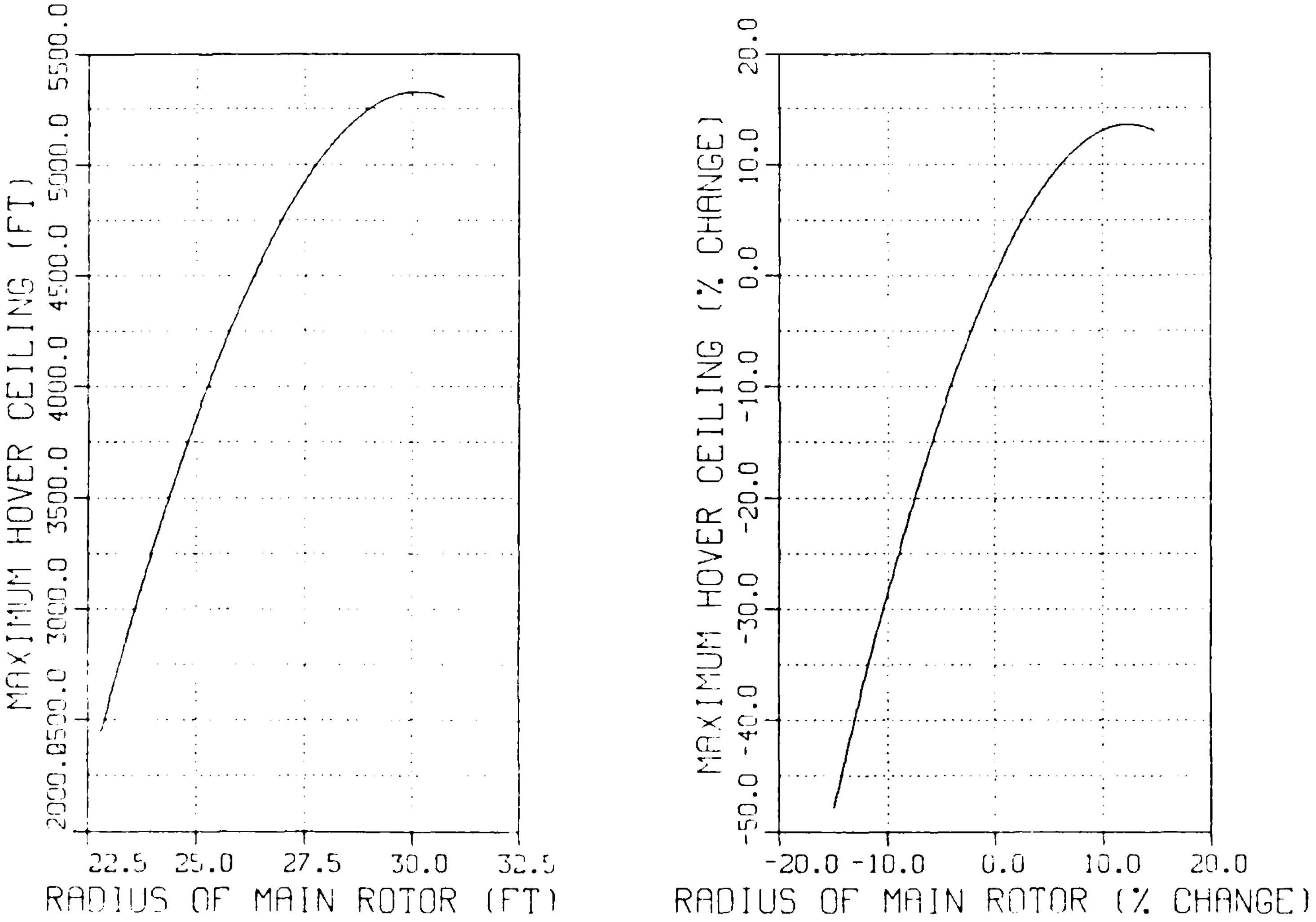

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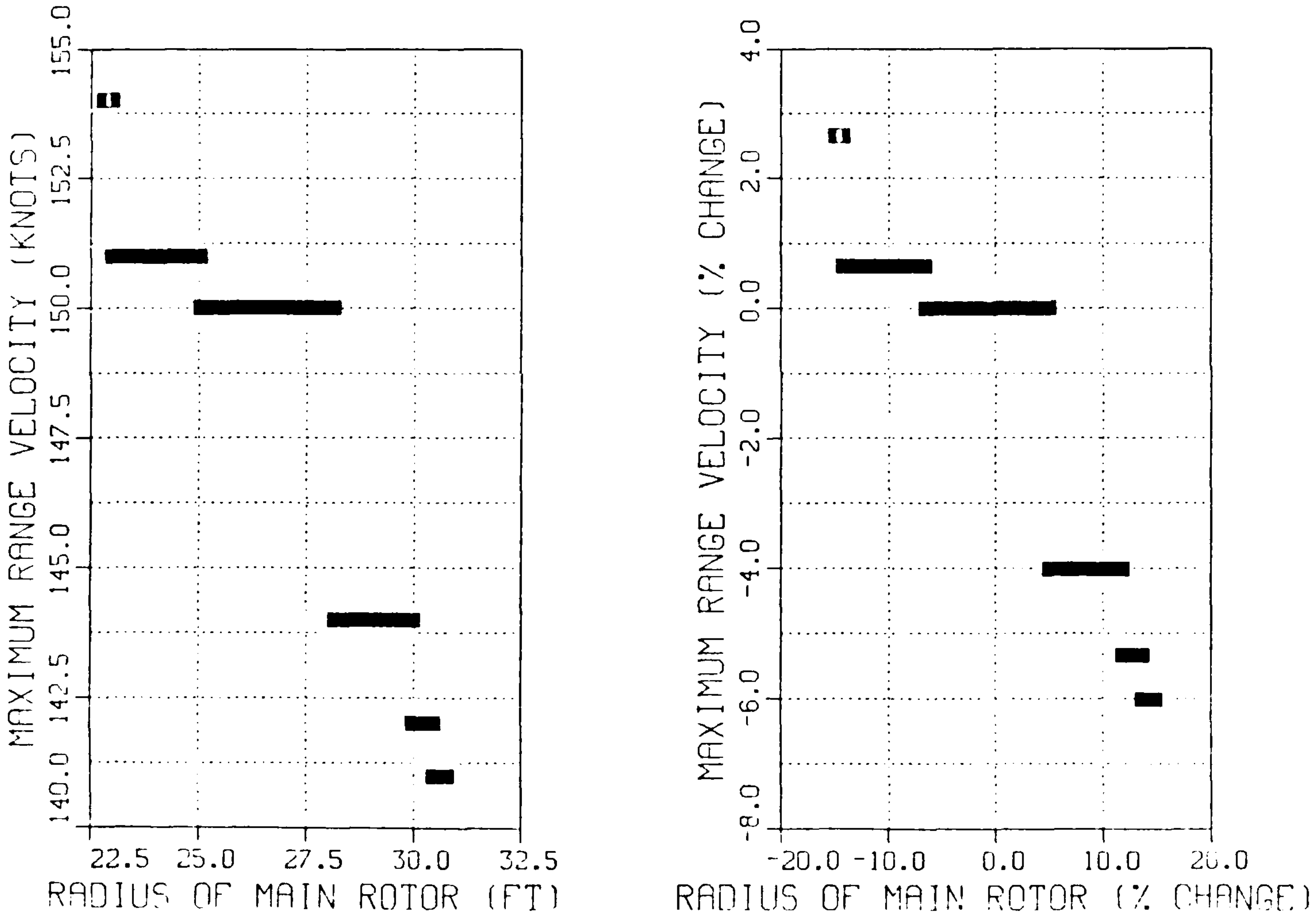

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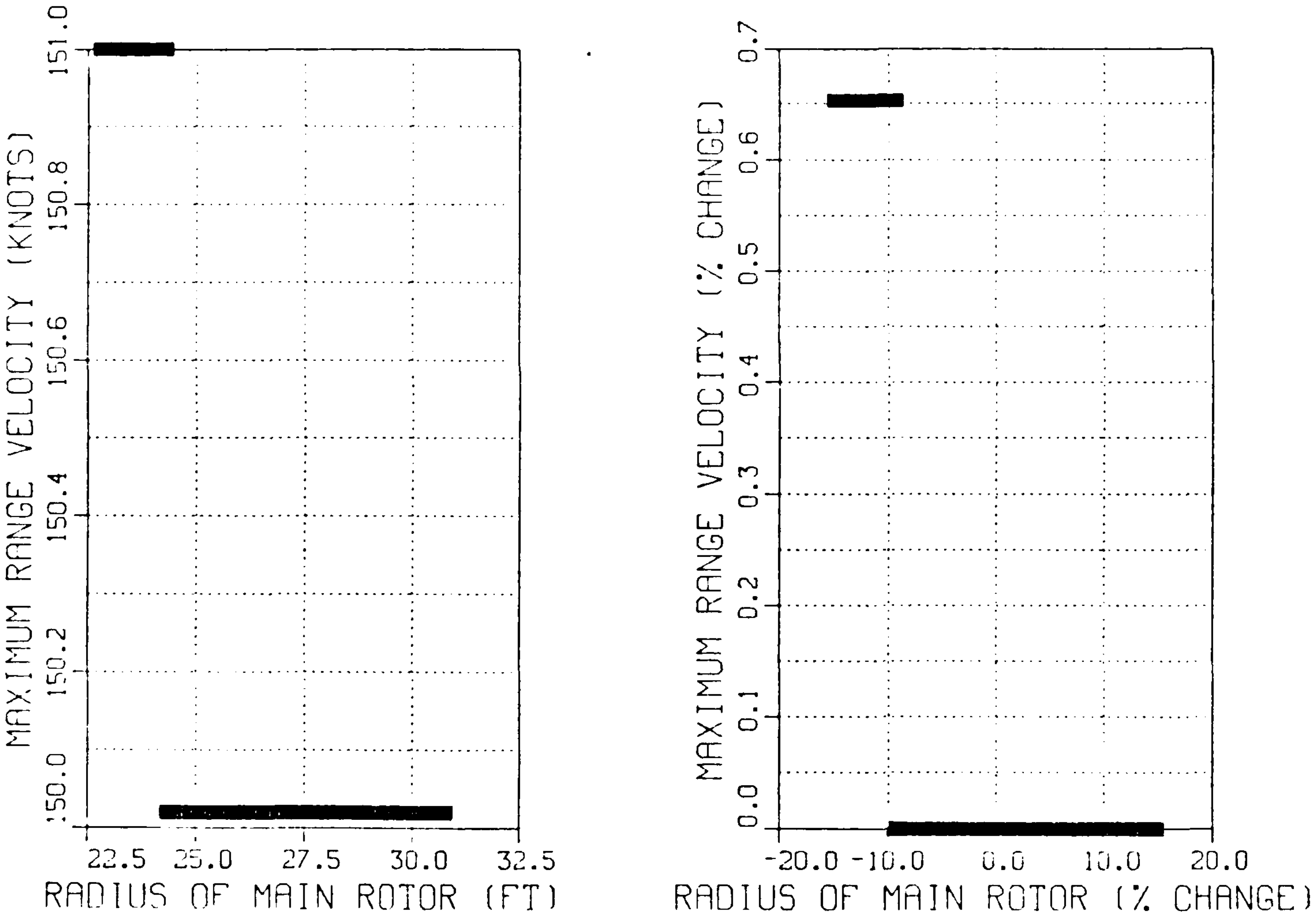
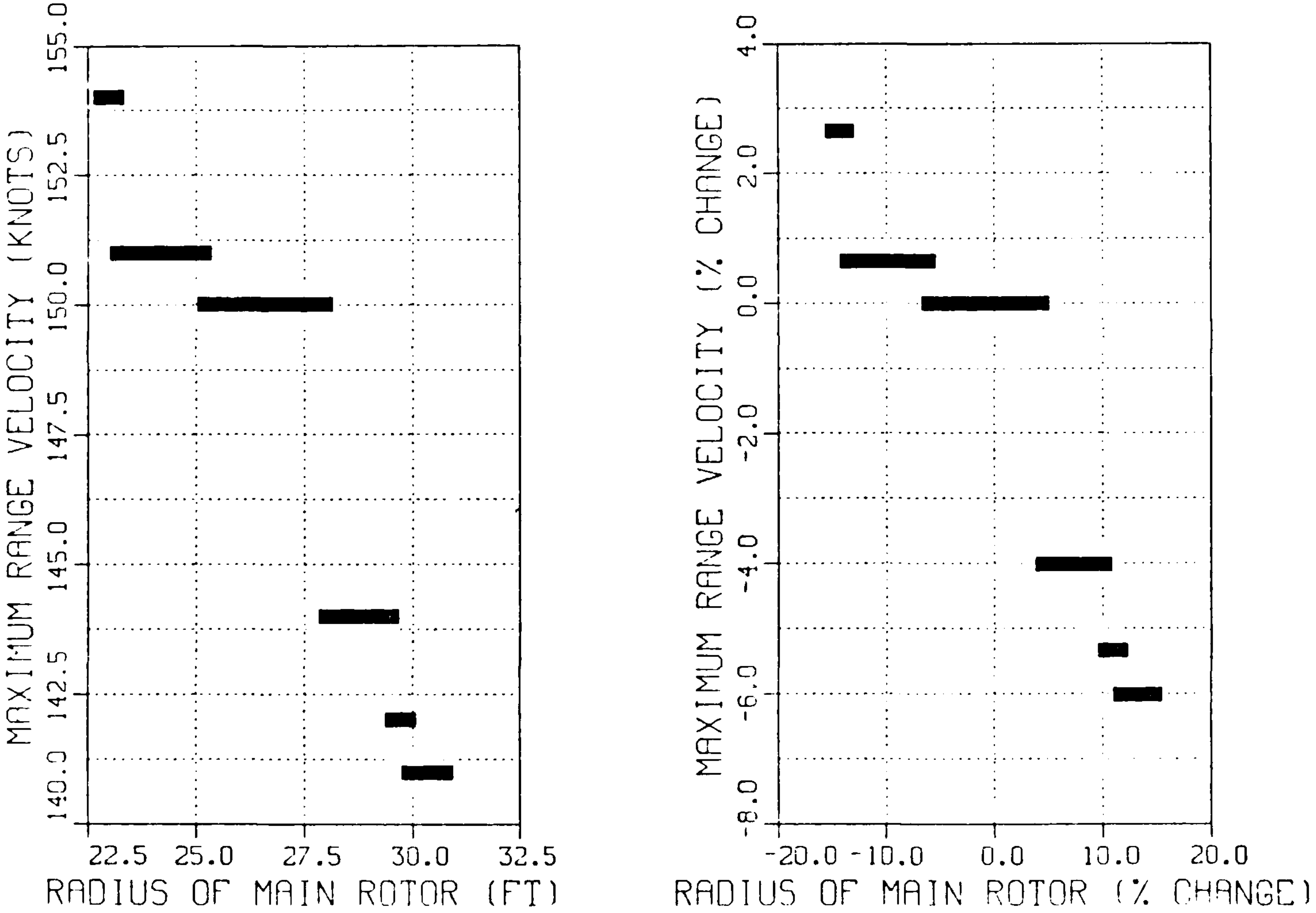
CHORD,ADVANCE RATIO & TIP VELOCITY
ALLOWED TO VARY WITH RADIUS

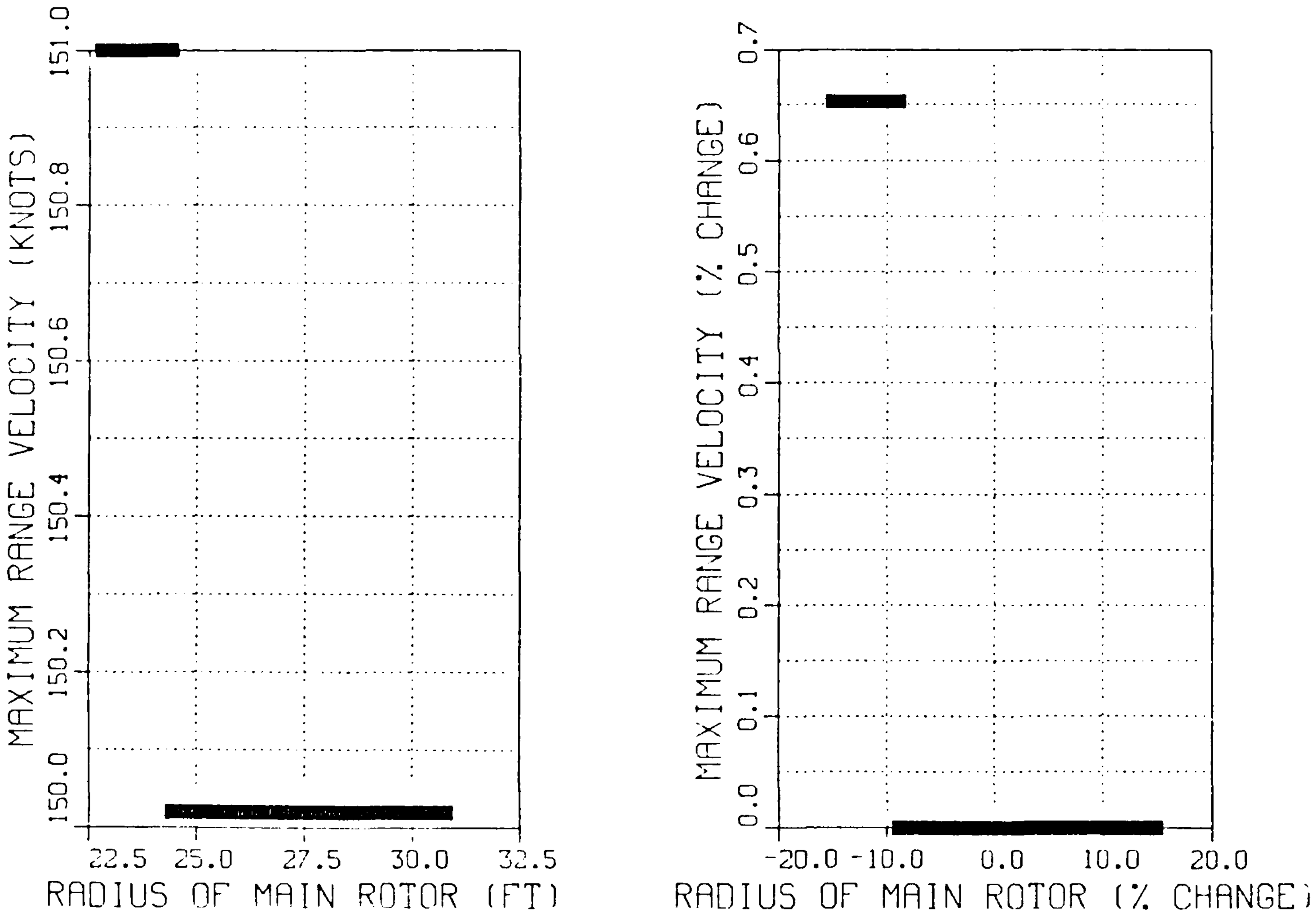


MAXIMUM RANGE VELOCITY VERSUS RADIUS CHANGE

CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT
SOLIDITY, ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS

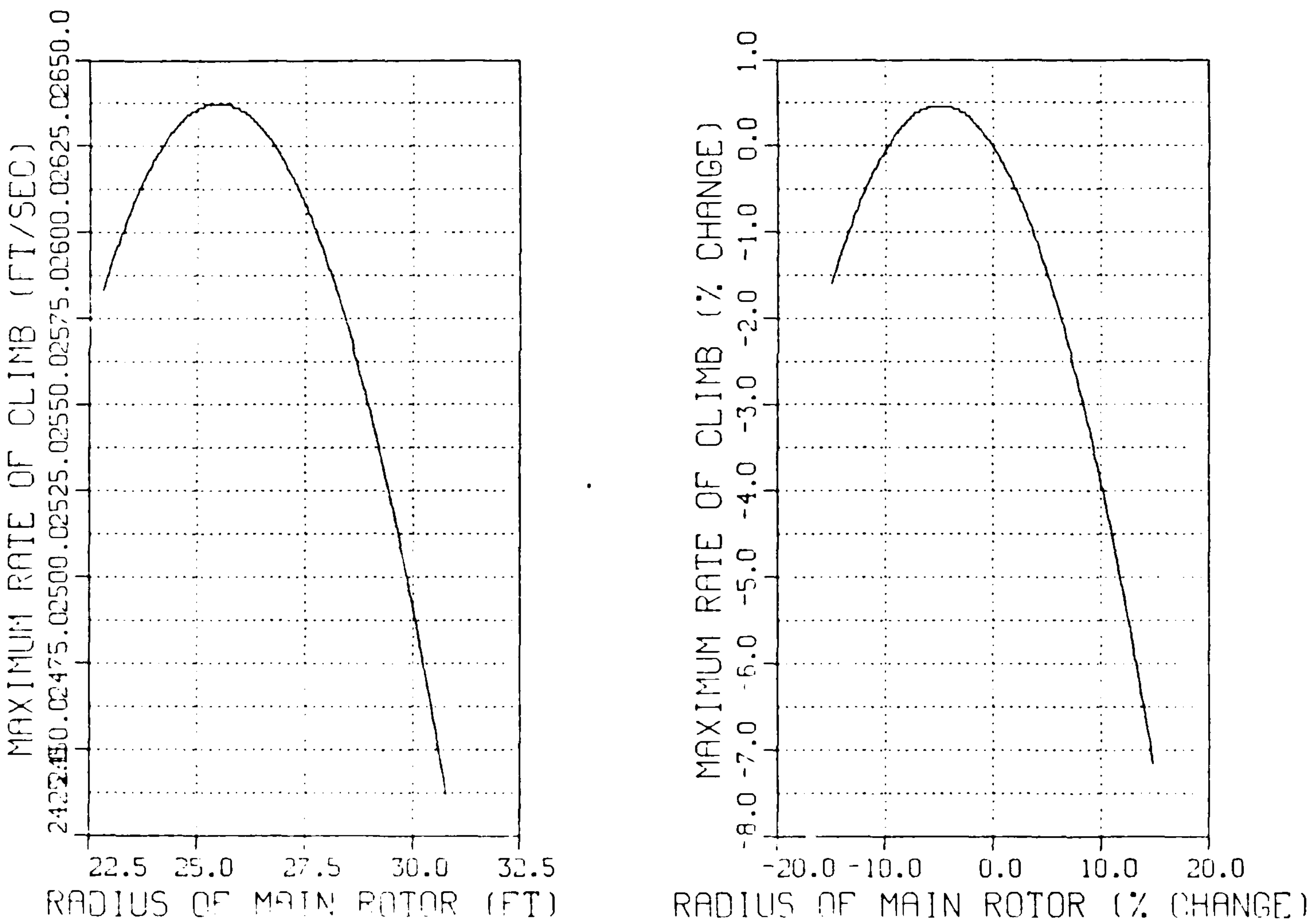


MAXIMUM RANGE VELOCITY VERSUS RADIUS CHANGE
CHORD & ROTATIONAL VELOCITY HELD CONSTANT
SOLIDITY, TIP VELOCITY & ADVANCE RATIO
ALLOWED TO VARY WITH RADIUS



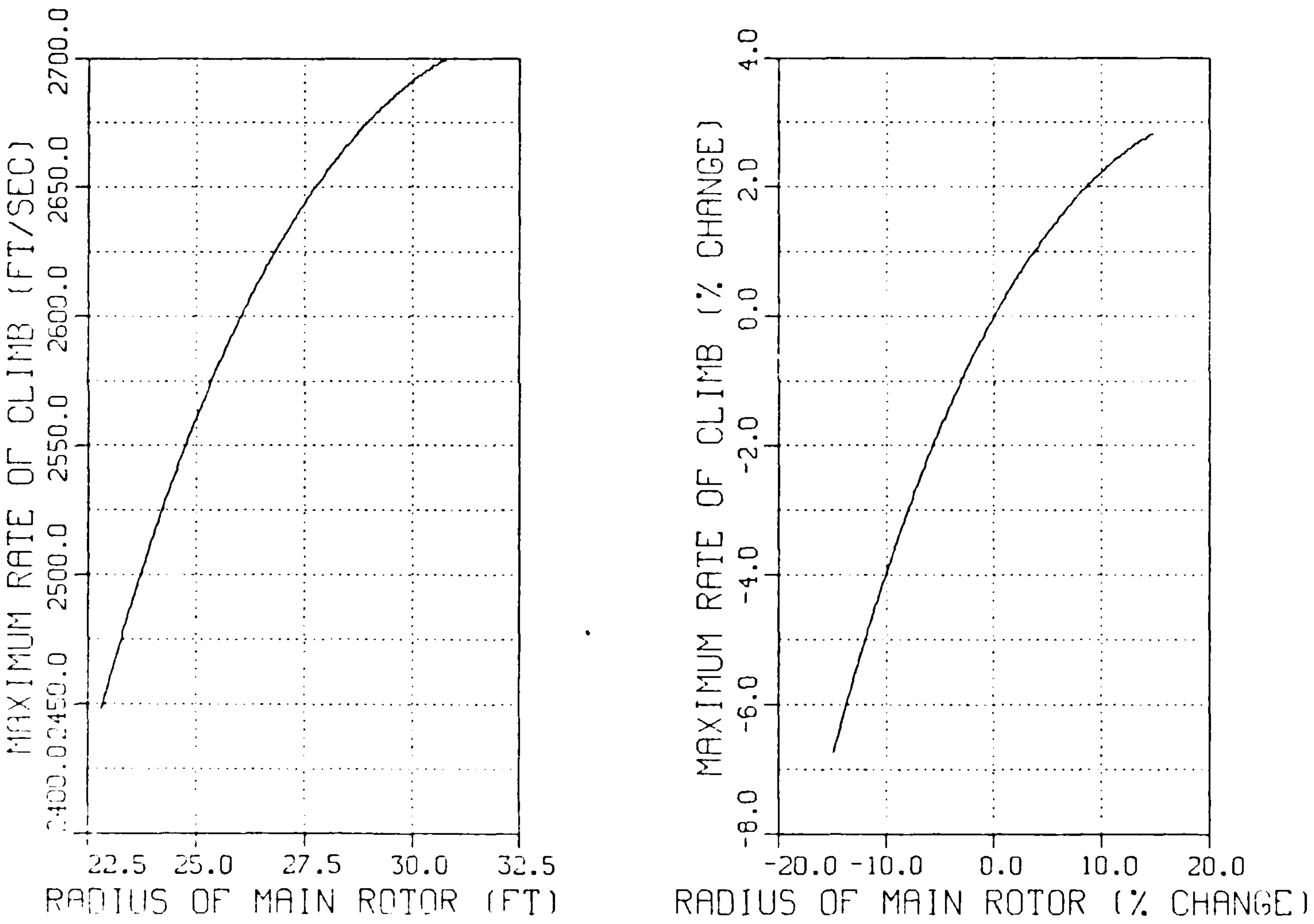
MAXIMUM RATE OF CLIMB VERSUS RADIUS CHANGE

CHORD & ROTATIONAL VELOCITY HELD CONSTANT
SOLIDITY, TIP VELOCITY & ADVANCE RATIO
ALLOWED TO VARY WITH RADIUS



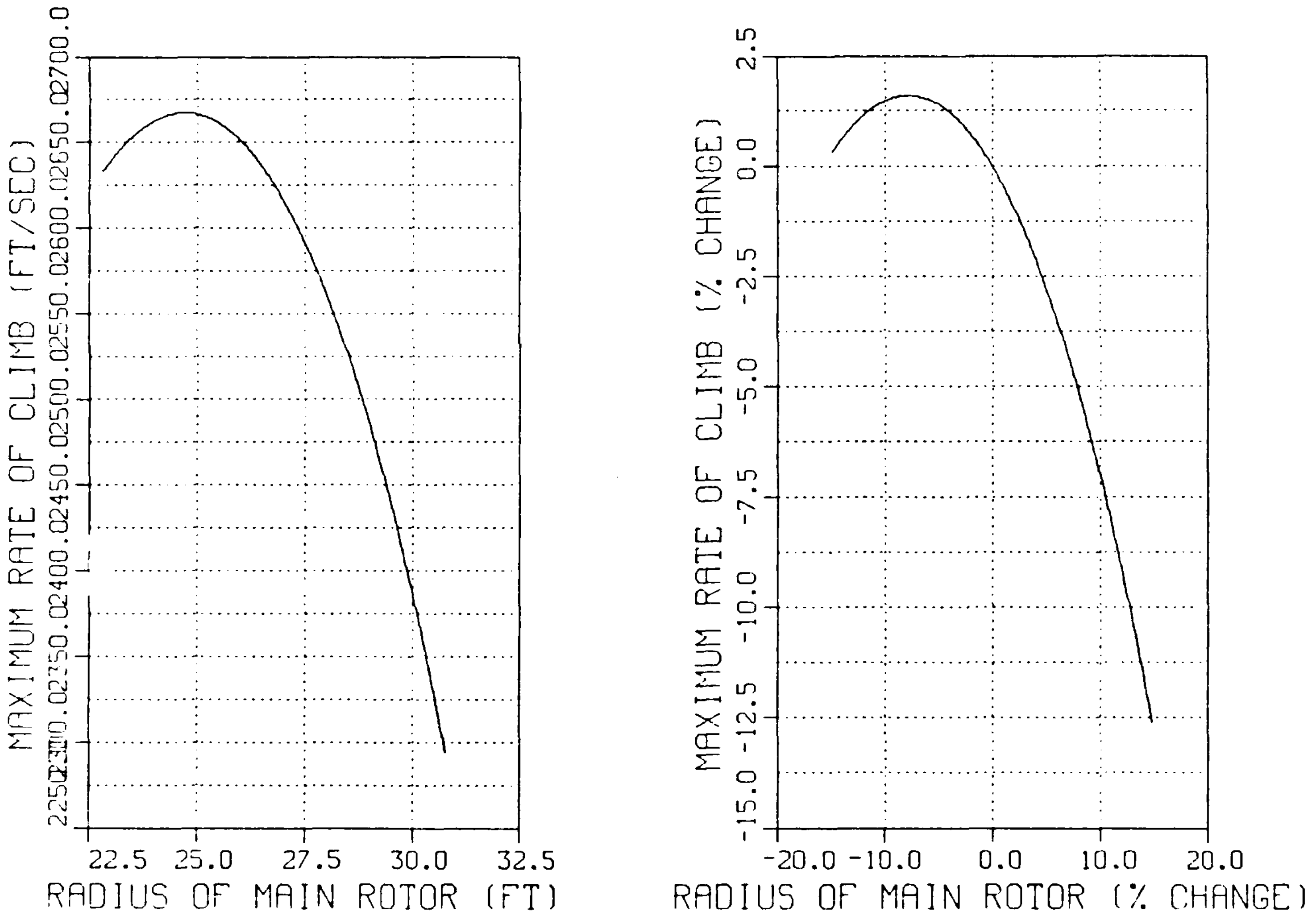
MAXIMUM RATE OF CLIMB VERSUS RADIUS CHANGE

CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT
SOLIDITY, ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS



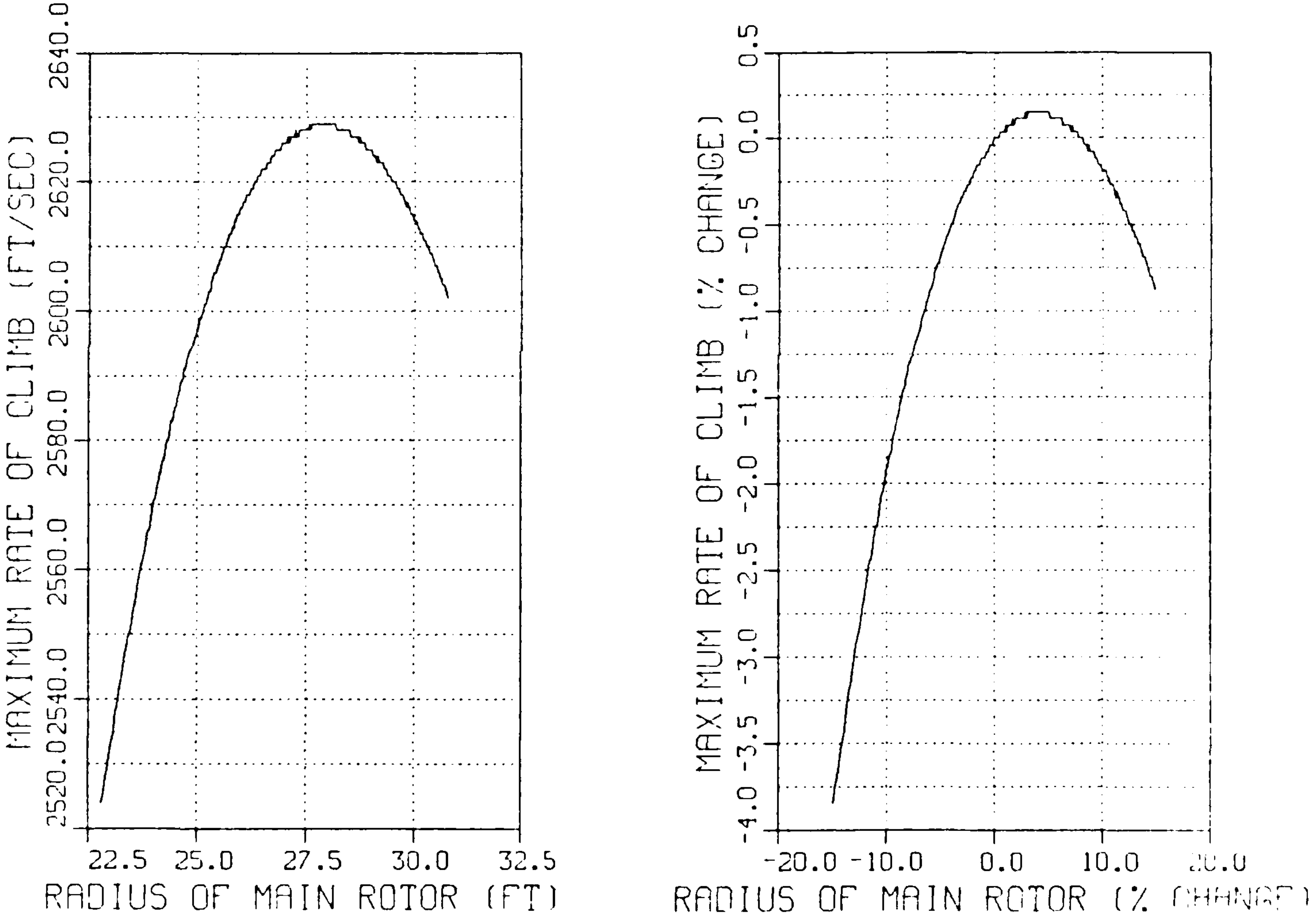
MAXIMUM RATE OF CLIMB VERSUS RADIUS CHANGE

SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT
CHORD,ADVANCE RATIO & TIP VELOCITY
ALLOWED TO VARY WITH RADIUS

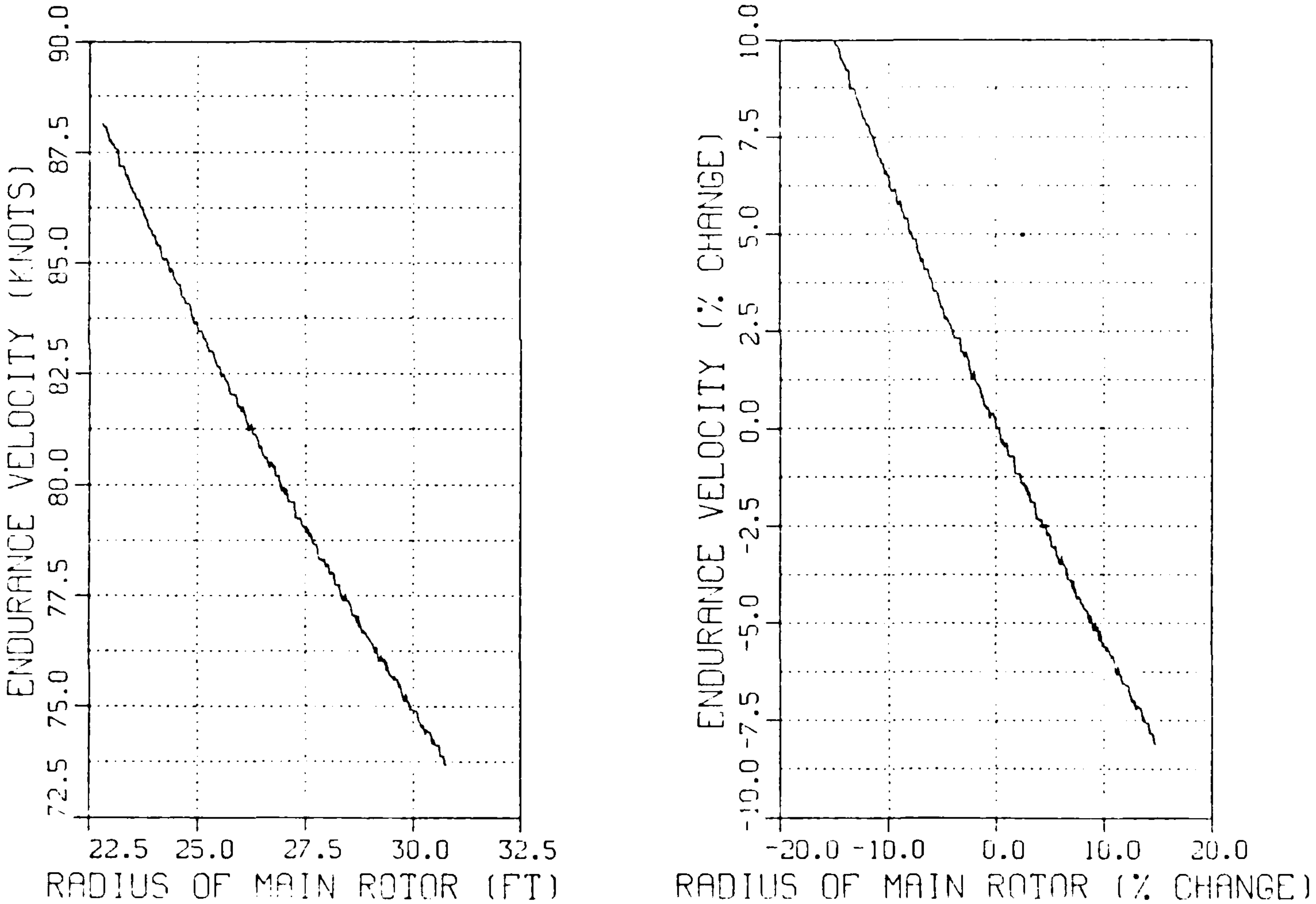


MAXIMUM RATE OF CLIMB VERSUS RADIUS CHANGE

SOLIDITY, ADVANCE RATIO & TIP VELOCITY HELD CONSTANT
CHORD & ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS

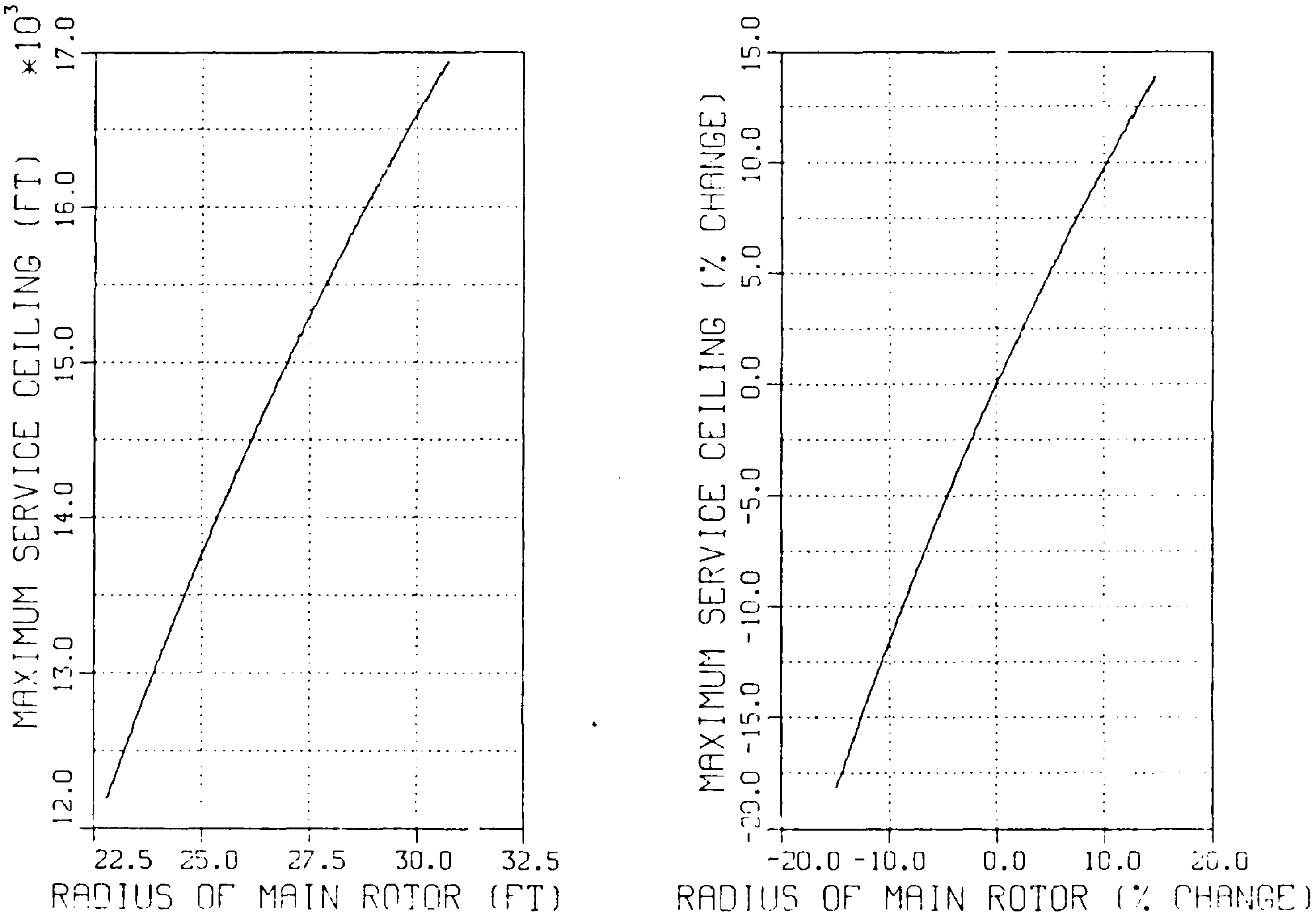


ENDURANCE VELOCITY VERSUS RADIUS
SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT
CHORD & ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS



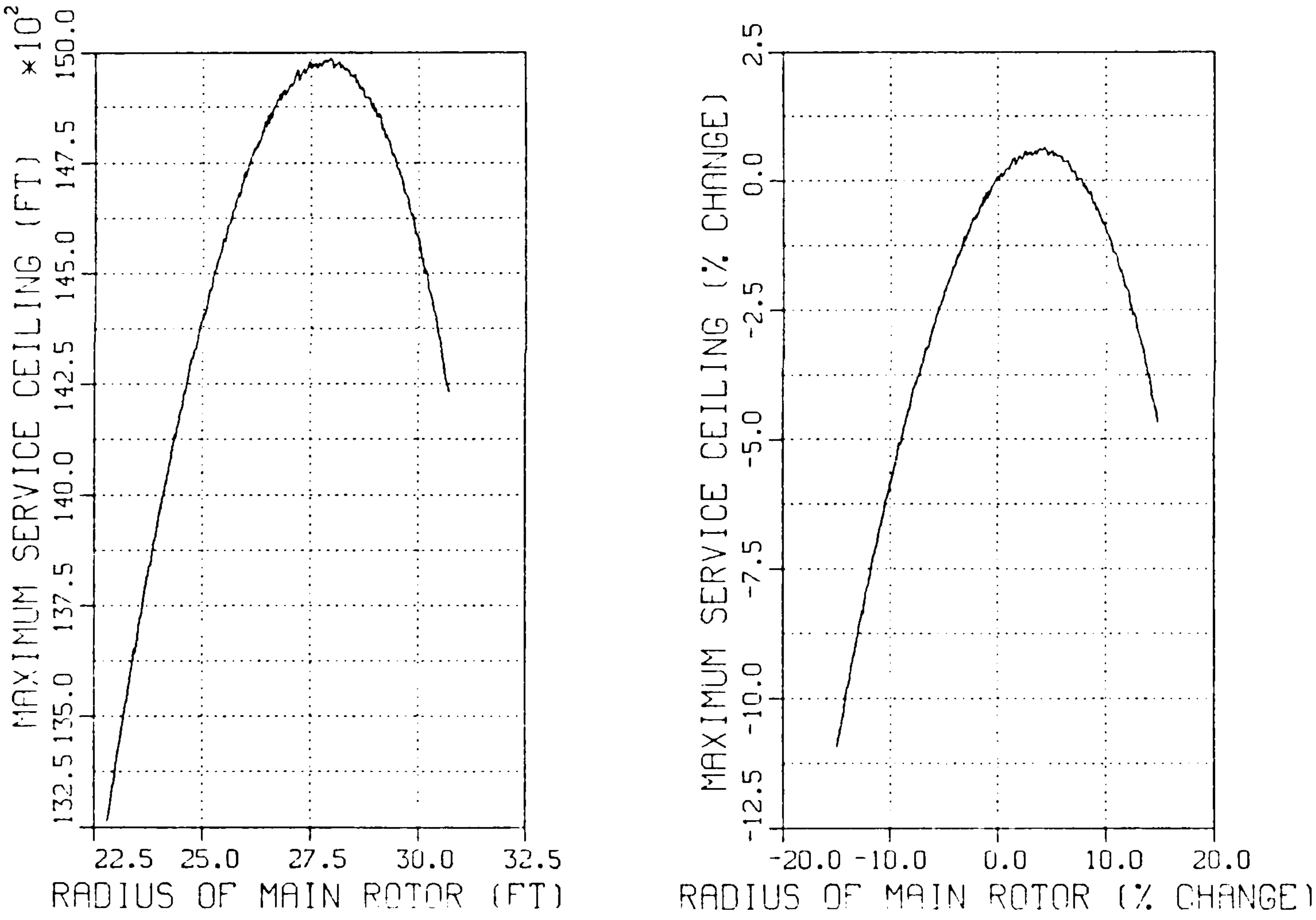
MAXIMUM SERVICE CEILING VERSUS RADIUS CHANGE

CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT
SOLIDITY, ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS



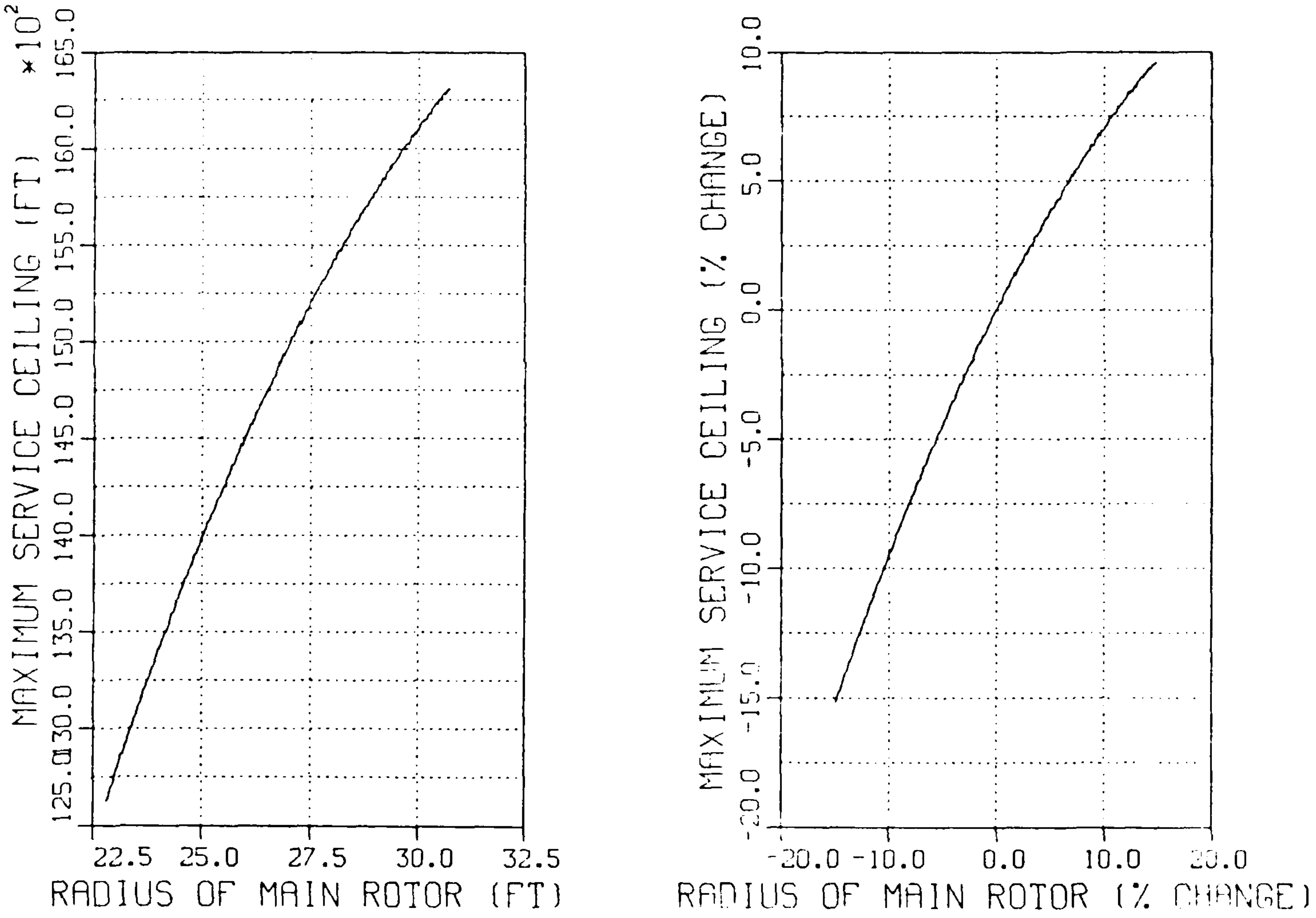
MAXIMUM SERVICE CEILING VERSUS RADIUS CHANGE

SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT
CHORD,ADVANCE RATIO & TIP VELOCITY
ALLOWED TO VARY WITH RADIUS



MAXIMUM SERVICE CEILING VERSUS RADIUS CHANGE

SOLIDITY, ADVANCE RATIO & TIP VELOCITY HELD CONSTANT
CHORD & ROTATIONAL VELOCITY
ALLOWED TO VARY WITH RADIUS



APPENDIX B

COMPUTER PROGRAM LISTING

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C                   PERFORMANCE DESIGN PROGRAM                             PEROC010
C                                                                          PEROC020
C                   COMPUTER PROGRAM LISTING                               PEROC030
C                                                                          PEROC040
C**********************************************************************    PEROC050
C                                                                          PEROC060
C          THIS PROGRAM WILL TAKE A SET OF HELICOPTER DESIGN DATA,         PEROC070
C     CALCULATE POWER REQUIRED, ENDURANCE VELOCITY,RATE OF CLIMB, RANGE    PEROC080
C     VELOCITY, HOVER CEILING AND SERVICE CEILING FOR THAT DATA.  IT       PEROC090
C     ALSO WILL CALCULATE THE PERFORMANCE FACTORS LISTED ABOVE OVER A      PEROC100
C     RANGE OF VALUES FOR THE GIVEN DATA.  IT THEN WILL PLOT THE RESULTS   PEROC110
C     VERSUS MAIN ROTOR RADIUS IN TWO FORMS. FORM 1 BEING THE PERFORMANCE
C     FACTOR VALUE VERSUS THE MAIN ROTOR RADIUS.  FORM 2 BEING A
C     PERCENT DIFFERENCE OF THE PERFORMANCE VALUE FROM THE VALUE OF THE
C     FACTOR AT THE GIVEN SPECIFICATION VALUE VERSUS THE PERCENT
C     DIFFERENCE OF THE RADIUS TO THE SPECIFICATION RADIUS.
C
C----------------------------------------------------------------------
C     TO RUN THE PROGRAM FOLLOW THESE STEPS:
C
C     1.   INPUT THE REQUIRED DATA IN LINES  173-207
C     2.   COMPILE PROGRAM USING: FORTHX PERFORM ( NOMAP
C          NOTE: IF YOU DO NOT USE ( NOMAP, YOU WILL NOT HAVE ENOUGH DISK
C          SPACE TO RUN THE PROGRAM
C     3.   GRAPH PROGRAM USING: DISSPLA PERFORM
C     4.   EXAMINE RESULTS BY USING: DISSPCF
C
C----------------------------------------------------------------------
C ***************     DEFINITION OF TERMS     *********************
C
C     AHAT - ZERO HORSEPOWER FUEL FLOW INTERCEPT
C     AMR - DISK AREA OF THE MAIN ROTOR (FT**2)
C     ARMR - ADVANCE RATIO OF THE MAIN ROTOR SYSTEM
C     ARTR - ADVANCE RATIO OF THE TAIL ROTOR SYSTEM
C     ATR - DISK AREA OF THE TAIL ROTOR (FT**2)
C     BHAT - AVERAGE SLOPE OF THE FUEL FLOW VS HORSEPOWER                  PEROC370
C     CDCMR - AVERAGE COEFFICIENT OF DRAG OF THE MAIN ROTOR BLADES         PEROC380
C     CDCTR - AVERAGE COEFFICIENT OF DRAG OF THE TAIL ROTOR BLADES         PEROC390
C     CEIL - SUBROUTINE TO CALCULATE MAX SERVICE CEILING                   PEROC400
C     CMR,CMR1 - CHORD LENGHT OF MAIN ROTOR (FT)                           PEROC410
C     CONST - SUBROUTINE TO CALCULATE COMMON USED CONSTANTS                PEROC420
C     CTMR - COEFFICIENT OF THRUST OF THE MAIN ROTOR SYSTEM                PEROC430
C     CTR - CHORD LENGHT OF TAIL ROTOR (FT)                                PEROC440
C     CTTR - COEFFICIENT OF THRUST OF THE TAIL ROTOR SYSYTEM               PEROC450
C     D.... - USED TO INDICATE A DIFFERENCE IN A VARIABLE, SEE VARIABLE    PEROC460
C     DA - DENSITY ALTITUDE (FT)                                           PEROC470
C     DELTA - PRESSURE RATIO (ALTITUDE/SSL)                                PEROC480
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C       DEN,DEN1 - DENSITY OF ATMOSPHERE (SLUGS/FT**3)                        PER00490
C       EFPAF - EFFECTIVE FLAT PLATE AREA - FORWARD (FT**2)                   PER00500
C       EFPAV - EFFECTIVE FLATE PLATE AREA - VERTICAL (FT**2)                 PER00510
C       ENDUR - SUBROUTINE TO CALCULATE ENDURANCE VELOCITY                    PER00520
C       ENGPOW - POWER AVAILABLE PER ENGINE (SHP)                             PER00530
C       FMERT - FIGURE OF MERIT                                               PER00540
C       GE - GROUND EFFECT FACTOR                                             PER00550
C       HD - ROTOR HEIGHT TO ROTOR DIAMETER RATIO                             PER00560
C       HOVALT - ALTITUDE FOR MAX HOVER CEILING (FT)                          PER00570
C       HOVER - SUBROUTINE TO CALCULATE MAX HOVER CEILING                     PER00580
C       IANS - PERFORMANCE FACTOR BEING CALCULATED                            PER00590
C       IBMR - NUMBER OF BLADES OF THE MAIN ROTOR SYSTEM                      PER00600
C       IBTR - NUMBER OF BLADES OF THE TAIL ROTOR SYSTEM                      PER00610
C       IENG - NUMBER OF ENGINES                                              PER00620
C       L - LENGHT OF TAIL BOOM (FT)                                          PER00630
C       MAX... - MAXIMUM VALUE FOR X OR Y AXIS                                PER00640
C       MAXRC - SUBROUTINE TO CALCULATE MAX RATE OF CLIMB                     PER00650
C       MIN... - MINIMUM VALUE FOR X OR Y AXIS                                PER00660
C       PA, PRESS1 - PRESSURE ALTITIDE (FT)                                   PER00670
C       PIMR - INDUCED POWER OF THE MAIN ROTOR WITH TIP LOSS & GROUND         PER00680
C              EFFECT (SHP)                                                   PER00690
C       PITR - INDUCED POWER OF THE TAIL ROTOR WITH TIP LOSS (SHP)            PER00700
C       PCMR - CLIMB POWER OF THE MAIN ROTOR (SHP)                            PER00710
C       PSHP - PHANTOM SHAFT HORSEPOWER (SHP)                                 PER00720
C       POMR - PROFILE POWER OF THE MAIN ROTOR (SHP)                          PER00730
C       POTR - PROFILE POWER OF THE TAIL ROTOR (SHP)                          PER00740
C       POWER - SUBROUTINE TO CALCULATE POWER REQUIREMENTS                    PER00750
C       POWMR - SUBROUTINE TO CALCULATE POWER REQUIREMENTS FOR MAIN ROTOR PER00760
C       POWTR - SUBROUTINE TO CALCULATE POWER REQUIREMENTS FOR TAIL ROTOR PER00770
C       PPMR - PARASITE POWER OF THE MAIN ROTOR (SHP)                         PER00780
C       POWAA - POWER AVAILABLE AT ALTITUDE (SHP)                             PER00790
C       PTAC - TOTAL POWER OF THE AIRCRAFT (SHP)                              PER00800
C       PTAVAL - POWER AVAILABLE FOR AIRCRAFT                                 PER00810
C       PTMIN - MINIMUM POWER REQUIRED FOR MAXIMUM ENDURANCE                  PER00820
C       PTMR - TOTAL POWER OF THE MAIN ROTOR (SHP)                            PER00830
C       PTTR - TOTAL POWER OF THE TAIL ROTOR (SHP)                            PER00840
C       RANGE - SUBROUTINE TO CALCULATE THE MAX RANGE VELOCITY                PER00850
C       RCMAX, RCMAXX - MAXIMUM RATE OF CLIMB (FT/MIN)                        PER00860
C       RHC - SUBROUTINE TO CALCULATE DENSITY                                 PER00870
C       RMR,RRMR - RADIUS OF THE MAIN ROTOR (FT)                              PER00880
C       RTR - RADIUS OF THE TAIL ROTOR (FT)                                   PER00890
C       RTHT - MAIN ROTOR HEIGHT ABOVE THE SKIDS OR WHEELS (FT)               PER00900
C       RVMR,RVMR1 - ROTATIONAL VELOCITY OF THE MAIN ROTOR (RAD/SEC)          PER00910
C       RVTR - ROTATIONAL VELOCITY OF THE TAIL ROTOR (RAD/SEC)                PER00920
C       SDMR,SDMR3 - SOLIDITY OF THE MAIM ROTOR                               PER00930
C       SDTR - SOLITITY OF THE TAIL ROTOR                                     PER00940
C       SEV,SEVALT - ALTITUDE FOR SERVICE CEILING (FT)                        PER00950
C       SFCM,SFCN,SFCC- SPECIFIC FUEL CONSUMPTION MILITARY,NORMAL,CRUISE   PER00960
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C       SHPM,SHPN,SHPC - SHAFT HORSEPOWER (SSL) MILITARY,NORMAL,CRUISE
C       SHPRAN - SHAFT HORSEPOWER REQUIRED AT RANGE VELOCITY (SHP)
C       SKDHT - SKID OR WHEEL HEIGHT ABOVE THE THE GROUND (FT)
C       TEMP,TEMP1 - TEMPERATURE (DEGREES F)
C       THETA - TEMPERATURE RATIO (ALTITUDE/SSL)
C       TLMR - TIP LOSS FACTOR OF THE MAIN ROTOR
C       TLTR - TIP LOSS FACTOR OF THE TAIL ROTOR
C       TTR - THRUST OF THE TAIL ROTOR (LBS FORCE)
C       VELMR - SUBROUTINE TO CALCULATE INDUCED VELOCITY FOR MAIN ROTOR
C       VELTR - SUBROUTINE TO CALCULATE INDUCED VELOCITY FOR TAIL ROTOR
C       VF,VFF,VF1 - FORWARD VELOCITY (KNOTS)
C       VFEND - VELOCITY FOR MAXIMUM ENDURANCE
C       VFRAN - RANGE VELOCITY (KTS)
C       VV - VERTICAL VELOCITY (FT/MIN)
C       VIHMR - INDUCED VELOCITY OF MAIN ROTOR AT A HOVER (FT/SEC)
C       VIHTR - INDUCED VELOCITY OF TAIL ROTOR AT A HOVER (FT/SEC)
C       VIMR - INDUCED VELOCITY OF MAIN ROTOR (FT/SEC)
C       VITR - INDUCED VELOCITY OF TAIL ROTOR (FT/SEC)
C       VITMR - INDUCED VELOCITY OF MAIN ROTOR IN FORWARD FLIGHT (FT/SEC)
C       VITTR - INDUCED VELOCITY OF TAIL ROTOR IN FORWARD FLIGHT (FT/SEC)
C       VIVMR - INDUCED VELOCITY OF MAIN ROTOR IN VERTICAL FLIGHT (FT/SEC)
C       VTMR, VTMR2 - TIP VELOCITY OF MAIN ROTOR (FT/SEC)
C       W - TOTAL WEIGHT OF THE HELICOPTER (LBS)
C       WDE,RANMAX - RATIO OF WEIGHT AND DRAG
C       WFM,WFN,WFC - FUEL FLOW RATE
C
C *************************************************************
C  ************************************************************
C**************************************************************
        IMPLICIT REAL (A-H,L-Z)
        COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),
      * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),
      * DFMERT(400),VFEND(400),DVFEND(400)
        COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,
      * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,
      * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,
      * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
      * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1,RRMR
        COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
      * PCTR(400),PTMR(400),PTTR(400),PTAC(400)
        COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
      * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
        COMMON /Y/DPIMR(400),DPOMR(400),DPPMR(400),DPCMR(400),DPTMR(400),
      * DPITR(400),DPOTR(400),DPTAC(400),DFTTR(400)
        COMMON /Z/ VFEND1(400),VFEND2(400),VFEND3(400),VFEND4(400)
C-------------------------------------------------------------
 5      CALL FRTCMS('CLRSCRN ')
        WRITE(5,6000)
      WRITE(5,6001)                                                     PER01450
      WRITE(5,6002)                                                     PER01460
      WRITE(5,6003)                                                     PER01470
      WRITE(5,6004)                                                     PER01480
      WRITE(5,6005)                                                     PER01490
      WRITE(5,6006)                                                     PER01500
      WRITE(5,6007)                                                     PER01510
      WRITE(5,6008)                                                     PER01520
      WRITE(5,6009)                                                     PER01530
      CALL REINT(IANS)                                                  PER01540
      CALL FRTCMS('CLRSCRN ')                                           PER01550
      IF(IANS .EQ. 3 .OR. IANS .EQ. 6) WRITE (5,6010)                   PER01560
      WRITE(5,6011)                                                     PER01570
 6000 FORMAT(10X,'YOU MAY CHOOSE ANY OF THE FOLLOWING PERFORMANCE ')    PER01580
 6001 FORMAT(10X,'FACTORS TO EXAMINE.  EACH ONE COULD TAKE 2-5 MINUTES')PER01590
 6002 FORMAT(10X,'TO RUN (ON AN AVERAGE). ',//)                         PER01600
 6003 FORMAT(15X,'1.   POWER REQUIREMENTS')                             PER01610
 6004 FORMAT(15X,'2.   MAXIMUM ENDURANCE VELOCITY')                     PER01620
 6005 FORMAT(15X,'3.   MAXIMUM RATE OF CLIMB')                          PER01630
 6006 FORMAT(15X,'4.   MAXIMUM RANGE VELOCITY')                         PER01640
 6007 FORMAT(15X,'5.   MAXIMUM HOVER CEILING (IGE)')                    PER01650
 6008 FORMAT(15X,'6.   MAXIMUM SERVICE CEILING')                        PER01660
 6009 FORMAT(10X,//,'ENTER THE NUMBER (1,2,3,4,5,OR 6) YOU WISH TO EXAMIPER01670
     *NE')                                                              PER01680
 6010 FORMAT(5X,'THIS MAY TAKE SOME TIME IF THERE ARE ALOT OF USERS')   PER01690
 6011 FORMAT(5X,'CALCULATING RESULTS')                                  PER01700
C*********************************************************************** PER01710
C                                                                       PER01720
C##########   INPUT DATA FOR HELICOPTER TO BE EXAMINED   #############  PER01730
C                                                                       PER01740
C*********************************************************************** PER01750
C---------------------- INPUT MAIN ROTOR DATA ------------------------- PER01760
      RADIUS = 26.8                                                     PER01770
C---------------------- +/- VALUE FROM SPEC RADIUS     ------------      PER01780
      DIFF = 4.0                                                        PER01790
      CMR1 = 1.75                                                       PER01800
      RVMR1 = 27.0                                                      PER01810
      CDCMR = 0.008                                                     PER01820
      IBMR = 4                                                          PER01830
C---------------------- INPUT TAIL ROTOR DATA ------------------------- PER01840
      RTR = 5.5                                                         PER01850
      CTR = 0.81                                                        PER01860
      RVTR = 124.6                                                      PER01870
      CDCTR = 0.008                                                     PER01880
      IBTR = 4                                                          PER01890
C---------------------- INPUT GENERAL AIRFRAME DATA ------------------- PER01900
      L = 31.5                                                          PER01910
      W = 20000.0                                                       PER01920
      EFPAF = 25.7                                                      PER01930
      EFPAV = 31.8                                                      PER01940
      RTHT = 11.2                                                       PER01950
C--------------------- INPUT ENGINE DATA -------------------------------PER01960
      IENG = 2                                                          PER01970
      SFCM = 0.46                                                       PER01980
      SFCN = 0.47                                                       PER01990
      SFCC = 0.51                                                       PER02000
      SHPM = 1561.0                                                     PER02010
      SHPN = 1318.0                                                     PER02020
      SHPC = 989.0                                                      PER02030
C---------- INPUT FLIGHT VELOCITY FOR INITIAL POWER CALCULATIONS ---    PER02040
      VF1 = 90.0                                                        PER02050
C=========   END OF REQUIRED INPUT INFORMATION  =====================PER02060
C===================================================================PER02070
      DO 3000 K = 1,4                                                   PER02080
      VV1 = 0.0                                                         PER02090
      PA = 0.0                                                          PER02100
      TEMP = 0.0                                                        PER02110
      DA = 0.0                                                          PER02120
      DENSSL = 0.00237694                                               PER02130
      SKDHT = 2500.0                                                    PER02140
      VF = VF1                                                          PER02150
      VV = VV1                                                          PER02160
      CMR = CMR1                                                        PER02170
      RVMR = RVMR1                                                      PER02180
      PIE = 3.141593                                                    PER02190
      SDMR3 = IBMR*CMR1 / (PIE*RADIUS)                                  PER02200
      VTMR2 = RVMR1*RADIUS                                              PER02210
      CALL RHO                                                          PER02220
      CALL RAD(DIFF,RADIUS,RRMR,RMR,DRMR,MINZ,MAXZ,DMIN,DMAX)           PER02230
      IF(IANS .NE. 1) GO TO 2800                                        PER02240
      CALL POWER                                                        PER02250
      GO TO 3000                                                        PER02260
 2800 IF(IANS .NE. 2) GO TO 2810                                        PER02270
      CALL ENDUR                                                        PER02280
      GO TO 3000                                                        PER02290
 2810 IF(IANS .NE. 3) GO TO 2820                                        PER02300
      CALL ENDUR                                                        PER02310
      CALL MAXPC                                                        PER02320
      GO TO 3000                                                        PER02330
 2820 IF(IANS .NE. 4) GO TO 2830                                        PER02340
      CALL RANGE                                                        PER02350
      GO TO 3000                                                        PER02360
 2830 IF(IANS .NE. 5) GO TO 2840                                        PER02370
      CALL HOVER                                                        PER02380
      GO TO 3000                                                        PER02390
 2840 IF(IANS .NE. 6) GO TO 2850                                        PER02400
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      CALL ENDUR                                                        PERO2410
      CALL CEIL                                                         PERO2420
      GO TO 3000                                                        PERO2430
 2850 GO TO 5                                                           PERO2440
 3000 CONTINUE                                                          PERO2450
      CALL DONEPL                                                       PERO2460
 5000 CONTINUE                                                          PERO2470
      STOP                                                              PERO2480
      END                                                               PERO2490
C*********************************************************************** PERO2500
C                                                                       PERO2510
C                     SUBROUTINES USED IN PRGRAM FOLLOW                 PERO2520
C                                                                       PERO2530
C*********************************************************************** PERO2540
C*********************************************************************** PERO2550
      SUBROUTINE RAD(DIFF,RADIUS,RRMR,RMR,DRMR,MINZ,MAXZ,DMIN,DMAX)     PERO2560
      IMPLICIT REAL (A-H,L-Z)                                           PERO2570
      DIMENSION RMR(400),DRMR(400)                                      PERO2580
      RRMR = RADIUS - DIFF                                              PERO2590
      DO 10 I = 1,324                                                   PERO2600
         RMR(I) = RRMR                                                  PERO2610
         IF (I .EQ. 163) RMR(I) = RADIUS                                PERO2620
         RRMR = RRMR + DIFF/162                                         PERO2630
   10 CONTINUE                                                          PERO2640
      DO 20 I = 1,324                                                   PERO2650
         DRMR(I) = ((RMR(I) - RMR(163)) / RMR(163)) * 100.0             PERO2660
   20 CONTINUE                                                          PERO2670
        DMIN = DRMR(1)                                                  PERO2680
        DMAX = DRMR(324)                                                PERO2690
        MINZ = RMR(1)                                                   PERO2700
        MAXZ = RMR(324)                                                 PERO2710
      RETURN                                                            PERO2720
      END                                                               PERO2730
C====================================================================== PERO2740
C=============                                 ======================== PERO2750
C===================      SUB-GROUP B     ============================= PERO2760
C=============      PERFORMANCE SUBROUTINES      ====================== PERO2770
C=================                      =============================== PERO2780
C======================================================================= PERO2790
C*********************************************************************** PERO2800
C                                                                       PERO2810
C  SUBROUTINE TO CALCULATE ALL PARTS OF THE TOTAL POWER REQUIREMENTS    PERO2820
C      AND FIGURE OF MERIT.                                             PERO2830
C                                                                       PERO2840
C*********************************************************************** PERO2850
C*********************************************************************** PERO2860
      SUBROUTINE POWER                                                  PERO2870
      IMPLICIT REAL (A-H,L-Z)                                           PERO2880
      INTEGER I,J,K                                                     PERO2890
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,       PERO2900
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SCMR,    PERO2910
     * SCTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,    PERO2920
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,PERO2930
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHFN,SHFC,CMR1,RVMR1,RRMR         PERO2940
      COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),     PERO2950
     * POTR(400),PTMR(400),PTTR(400),PTAC(400)                          PERO2960
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,     PERO2970
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)   PERO2980
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),         PERO2990
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),      PERO3000
     * DFMERT(400),VFEND(400),DVFEND(400)                               PERO3010
      COMMON /Y/DPIMR(400),DPOMR(400),DPPMR(400),DPCMR(400),DPTMR(400), PERO3020
     * DPITR(400),DPOTR(400),DPTAC(400),DPTTR(400)                      PERO3030
C-----------------------------------------------------------------------PERO3040
      MAX = 0.0                                                         PERO3050
      MAXA = 0.0                                                        PERO3060
      DO 40 I = 1,324                                                   PERO3070
         CALL CONST                                                     PERO3080
         AMR = RMR(I)**2.0*PIE                                          PERO3090
         IF(K .NE.1) GO TO 8                                            PERO3100
            VTMR = RVMR*RMR(I)                                          PERO3110
            ARMR = VF / (RVMR*RMR(I))                                   PERO3120
            SCMR = IBMR*CMR / (PIE*RMR(I))                              PERO3130
8        IF(K .NE. 2) GO TO 10                                          PERO3140
            RVMR = VTMR2/RMR(I)                                         PERO3150
            VTMR = RVMR*RMR(I)                                          PERO3160
            ARMR = VF / (RVMR*RMR(I))                                   PERO3170
            SCMR = IBMR*CMR1 / (PIE*RMR(I))                             PERO3180
10       IF(K .NE. 3) GO TO 12                                          PERO3190
            CMR = SDMR3*PIE*RMR(I)/IBMR                                 PERO3200
            SCMR = IBMR*CMR / (PIE*RMR(I))                              PERO3210
            RVMR = RVMR1                                                PERO3220
            ARMR = VF / (RVMR*RMR(I))                                   PERO3230
            VTMR = RVMR*RMR(I)                                          PERO3240
12       IF(K .NE. 4) GO TO 14                                          PERO3250
            CMR = SDMR3*PIE*RMR(I)/IBMR                                 PERO3260
            SCMR = IBMR*CMR / (PIE*RMR(I))                              PERO3270
            RVMR = VTMR2/RMR(I)                                         PERO3280
            VTMR = RVMR*RMR(I)                                          PERO3290
            ARMR = VF / (RVMR*RMR(I))                                   PERO3300
14       CALL VELMR                                                     PERO3310
         CALL FCWMR                                                     PERO3320
         CALL VELTR                                                     PERO3330
         CALL FCWTR                                                     PERO3340
         IF(PIMR(I) .GT. MAXA) MAXA = PIMR(I)                           PERO3350
         IF(POMR(I) .GT. MAXA) MAXA = POMR(I)                           PERO3360
      IF(PPMR(I) .GT. MAXA) MAXA = PPMR(I)                             PER03370
      IF(VV .LE. 0.0 ) GO TO 20                                         PER03380
      IF(PCMR(I) .GT. MAXA) MAXA = PCMR(I)                              PER03390
20    IF(PTAC(I) .GT. MAX) MAX = PTAC(I)                                PER03400
      VF = VF / 1.68889                                                 PER03410
      VV = VV * 60.0                                                    PER03420
40    CONTINUE                                                          PER03430
C-----------------------------------------------------------------------PER03440
      MINY = 500.0                                                      PER03450
      MAXY = -500.0                                                     PER03460
      MINX = 500.0                                                      PER03470
      MAXX = -500.0                                                     PER03480
      DO 140 I = 1,324                                                  PER03490
         DPIMR(I) = ((PIMR(I) - PIMR(163)) / PIMR(163)) * 100.0         PER03500
           IF(DPIMR(I) .GT. MAXX) MAXX = DPIMR(I)                       PER03510
           IF(DPIMR(I) .LT. MINX) MINX = DPIMR(I)                       PER03520
         DPOMR(I) = ((POMR(I) - POMR(163)) / POMR(163)) * 100.0         PER03530
           IF(DPOMR(I) .GT. MAXX) MAXX = DPOMR(I)                       PER03540
           IF(DPOMR(I) .LT. MINX) MINX = DPOMR(I)                       PER03550
         DPPMR(I) = ((PPMR(I) - PPMR(163)) / PPMR(163)) * 100.0         PER03560
           IF(DPPMR(I) .GT. MAXX) MAXX = DPPMR(I)                       PER03570
           IF(DPPMR(I) .LT. MINX) MINX = DPPMR(I)                       PER03580
         IF(VV .LE. 0.0 ) GO TO 120                                     PER03590
         DPCMR(I) = ((PCMR(I) - PCMR(163)) / PCMR(163)) * 100.0         PER03600
           IF(DPCMR(I) .GT. MAXX) MAXX = DPCMR(I)                       PER03610
           IF(DPCMR(I) .LT. MINX) MINX = DPCMR(I)                       PER03620
120      DPTMR(I) = ((PTMR(I) - PTMR(163)) / PTMR(163)) * 100.0         PER03630
         DPITR(I) = ((PITR(I) - PITR(163)) / PITR(163)) * 100.0         PER03640
         DPOTR(I) = ((POTR(I) - POTR(163)) / POTR(163)) * 100.0         PER03650
         DPTTR(I) = ((PTTR(I) - PTTR(163)) / PTTR(163)) * 100.0         PER03660
         DPTAC(I) = ((PTAC(I) - PTAC(163)) / PTAC(163)) * 100.0         PER03670
          IF(DPTAC(I) .GT. MAXY) MAXY = DPTAC(I)                        PER03680
          IF(DPTMR(I) .GT. MAXY) MAXY = DPTMR(I)                        PER03690
          IF(DPTTR(I) .GT. MAXY) MAXY = DPTTR(I)                        PER03700
          IF(DPTAC(I) .LT. MINY) MINY = DPTAC(I)                        PER03710
          IF(DPTMR(I) .LT. MINY) MINY = DPTMR(I)                        PER03720
          IF(DPTTR(I) .LT. MINY) MINY = DPTTR(I)                        PER03730
140   CONTINUE                                                          PER03740
      CALL GRAFIC                                                       PER03750
      CALL GRAFID                                                       PER03760
C---------------------------------------------------------------------- PER03770
      VF = 0.0                                                          PER03780
      MINB = 1.0                                                        PER03790
      MAXB = 0.0                                                        PER03800
      DO 150 I = 1,324                                                  PER03810
         CALL CONST                                                     PER03820
         AMR = RMR(I)**2.0*PIE                                          PER03830
         IF(K .NE.1) GO TO 142                                          PER03840
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            VTMR =  RVMR*RMR(I)                                         PER03850
            ARMR =  VF /  (RVMR*RMR(I))                                 PER03860
            SDMR =  IBMR*CMR / (PIE*RMR(I))                             PER03870
142       IF(K .NE. 2) GO TO 144                                        PER03880
            RVMR =  VTMR2/RMR(I)                                        PER03890
            VTMR =  RVMR*RMR(I)                                         PER03900
            ARMR =  VF /  (RVMR*RMR(I))                                 PER03910
            SDMR =  IBMR*CMR1 /  (PIE*RMR(I))                           PER03920
144       IF(K .NE. 3) GO TO 146                                        PER03930
            CMR = SDMR3*PIE*RMR(I)/IBMR                                 PER03940
            SDMR =  IBMR*CMR / (PIE*RMR(I))                             PER03950
            RVMR =  RVMR1                                               PER03960
            ARMR =  VF /  (RVMR*RMR(I))                                 PER03970
            VTMR =  RVMR*RMR(I)                                         PER03980
146       IF(K .NE. 4) GO TO 148                                        PER03990
            CMR = SDMR3*PIE*RMR(I)/IBMR                                 PER04000
            SDMR =  IBMR*CMR / (PIE*RMR(I))                             PER04010
            RVMR =  VTMR2/RMR(I)                                        PER04020
            VTMR =  RVMR*RMR(I)                                         PER04030
            ARMR =  VF /  (RVMR*RMR(I))                                 PER04040
148       CALL VELMR                                                    PER04050
          CALL POWMR                                                    PER04060
          CALL VELTR                                                    PER04070
          CALL FCWTR                                                    PER04080
          FMERT(I) = PIMR(I) / (PIMR(I) + FCMR(I))                      PER04090
          IF(FMERT(I) .GT. MAXB) MAXB = FMERT(I)                        PER04100
          IF(FMERT(I) .LT. MINB) MINB = FMERT(I)                        PER04110
150      CONTINUE                                                       PER04120
C-----------------------------------------------------------------------PER04130
      MINC = 500.0                                                      PER04140
      MAXC = -500.0                                                     PER04150
      DO 155 I = 1,324                                                  PER04160
         DFMERT(I) = ((FMERT(I) - FMERT(163)) / FMERT(163)) * 100.0     PER04170
           IF(DFMERT(I) .GT. MAXC) MAXC = DFMERT(I)                     PER04180
           IF(DFMERT(I) .LT. MINC) MINC = DFMERT(I)                     PER04190
155   CONTINUE                                                          PER04200
         CALL GRAFIE                                                    PER04210
      RETURN                                                            PER04220
      END                                                               PER04230
C*********************************************************************** PER04240
C                                                                       PER04250
C     SUBROUTINE TO CALCULATE THE ENDURANCE  VELOCITY                   PER04260
C                                                                       PER04270
C*********************************************************************** PER04280
C*********************************************************************** PER04290
      SUBROUTINE ENDUR                                                  PER04300
      IMPLICIT REAL (A-H,L-Z)                                           PER04310
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,       PER04320
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     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADILS,RTR,RTHT,RVMR,RVTR,SCMR,      PER04330
     * SCTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,CENSSL,PIE,PTMIN(400),VIMR,      PER04340
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,  PER04350
     * VTMR2,CIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1,RRMR           PER04360
       CCMMCN /B/ PIMR(400),POMR(400 ),PPMR(400),PCMR(400 ),PITR(400),    PER04370
     * POTR(400),PTMR(400),PTTR(400),PTAC(400)                            PER04380
       CCMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,      PER04390
     * MAXZ,CMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)     PER04400
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),           PER04410
     * HCVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),        PER04420
     * DFMERT(400),VFEND(400),DVFEND(400)                                 PER04430
       CCMMCN /Z/ VFEND1(400),VFEND2(400),VFEND3(400),VFEND4(400)         PER04440
C-------------------------------------------------------------------------PER04450
      MAX = C.C                                                           PER04460
      MIN = 500.0                                                         PER04470
      CALL RHC                                                            PER04480
      DO 280 I = 1,324                                                    PER04490
         AMR = RMR(I)**2.0*PIE                                            PER04500
         IF(K .NE.1) GO TC 148                                            PER04510
            RVMR = RVMR1                                                  PER04520
            VTMR = RVMR*RMR(I)                                            PER04530
            SCMR = IBMR*CMR / (PIE*RMR(I))                                PER04540
148      IF(K .NE. 2) GO TO 150                                           PER04550
            RVMR = VTMR2/RMR(I)                                           PER04560
            VTMR = RVMR*RMR(I)                                            PER04570
            SCMR = IBMR*CMR1 / (PIE*RMR(I))                               PER04580
150      IF(K .NE. 3) GO TO 152                                           PER04590
            CMR = SDMR3*PIE*RMR(I)/IBMR                                   PER04600
            SCMR = IBMR*CMR / (PIE*RMR(I))                                PER04610
            RVMR = RVMR1                                                  PER04620
            VTMR = RVMR*RMR(I)                                            PER04630
152      IF(K .NE. 4) GO TO 154                                           PER04640
            CMR = SDMR3*PIE*RMR(I)/IBMR                                   PER04650
            SCMR = IBMR*CMR / (PIE*RMR(I))                                PER04660
            RVMR = VTMR2/RMR(I)                                           PER04670
            VTMR = RVMR*RMR(I)                                            PER04680
154      PTMIN(I) = 10000.0                                               PER04690
         VFEND(I) = 0.0                                                   PER04700
         CO 180 J = 1,20                                                  PER04710
            VF = FLOAT(J) * 10.0                                          PER04720
            CALL CONST                                                    PER04730
            ARMR = VF / (RVMR*RMR(I))                                     PER04740
            CALL VELMR                                                    PER04750
            CALL POWMR                                                    PER04760
            CALL VELTR                                                    PER04770
            CALL POWTR                                                    PER04780
            IF (PTAC(I) .GT. PTMIN(I)) GC TO 160                          PER04790
               PTMIN(I) = PTAC(I)                                         PER04800
```

```
                VFEND(I) = VF/1.68889
160           CCNTINUE
180        CONTINUE
           VFENC(I) = VFENC(I) - 10.0
           VFF = VFEND(I)
           CO 22C J = 1,20
              VF = (FLOAT(J)-1.0) + VFF
              CALL CONST
              ARMR = VF /  (RVMR*RMR(I))
              CALL VELMR
              CALL POWMR
              CALL VELTR
              CALL POWTR
              IF (PTAC(I) .GT. PTMIN(I)) GC TC 200
                 PTMIN(I) = PTAC(I)
                 VFEND(I) = VF/1.68889
200           CCNTINUE
220        CONTINLE
           VFENC(I) = VFEND(I) - 1.0
           VFF = VFEND(I)
           DO 260 J = 1,200
              VF = ((FLOAT(J)/100)-0.01) + VFF
              CALL CONST
              ARMR = VF /  (RVMR*RMR(I))
              CALL VELMR
              CALL POWMR
              CALL VELTR
              CALL POWTR
              IF (PTAC(I) .GT. PTMIN(I)) GC TC 240
                 PTMIN(I) = PTAC(I)
                 VFEND(I) = VF/1.68889
240           CONTINUE
260        CONTINUE
           VFENC(I) = VFEND(I) - 0.01
           IF(K .EQ. 1) VFEND1(I) = VFEND(I)
           IF(K .EC. 2) VFEND2(I) = VFEND(I)
           IF(K .EC. 3) VFEND3(I) = VFEND(I)
           IF(K .EC. 4) VFEND4(I) = VFEND(I)
        IF(VFENC(I) .LT. MIN) MIN = VFEND(I)
        IF(VFENC(I) .GT. MAX) MAX = VFEND(I)
280     CONTINLE
C-------------------------------------------------------------------
        MAXY = -5C0.0
        MINY = 500.C
        DO 480 I = 1,324
            DVFEND(I) = ((VFENC(I) - VFEND(163)) / VFEND(163)) * 100.0
            IF(CVFEND(I) .GT. MAXY) MAXY = CVFEND(I)
            IF(CVFEND(I) .LT. MINY) MINY = CVFEND(I)
```

```
C
C     SUBROUTINE TO CREATE GRAPHS FOR POWER AND FIGURE OF MERIT
C         VS RADIUS
C
C***********************************************************************
C***********************************************************************
      SUBROUTINE GRAFIC
      IMPLICIT REAL (A-H,L-Z)
       COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
     * PCTR(400),PTMR(400),PTTR(400),PTAC(400)
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
       COMMON /Y/DPIMR(400),DPOMR(400),DPPMR(400),DPCMR(400),DPTMR(400),
     * DPITR(400),DPOTR(400),DPTAC(400),DPTTR(400)
      CALL COMPRS
      CALL PAGE (11.0,8.5)
      CALL PHYSOR(1.5,1.5)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)
      CALL YNAME ('POWER REQUIRED (SHP)$',100)
      CALL GRAF (MINZ,'SCALE',MAXZ,0.0,'SCALE',MAX)
      CALL LEGLIN
      CALL DASH
      CALL CURVE (RMR,PTTR,322,0)
      CALL CHNDOT
      CALL CURVE (RMR,PTMR,322,0)
      CALL CHNDSH
      CALL CURVE (RMR,PTAC,322,0)
      MAXLIN=LINEST(TEXT,100,30)
      CALL HEIGHT(0.1)
      CALL LINES('TAIL ROTOR POWER$',TEXT,1)
      CALL LINES('MAIN ROTOR POWER$',TEXT,2)
      CALL LINES('TOTAL POWER$',TEXT,3)
      CALL LEGEND(TEXT,3,0.4,1.5)
      CALL BLREC(0.3,1.42,1.95,0.75,1.2)
      CALL RESET('HEIGHT')
      CALL DOT
      CALL GRID (1,2)
      CALL ENDGR(0)
C----------------------------------------------------------------------
      CALL PHYSOR(5.5,1.5)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)
      CALL YNAME ('POWER REQUIRED (% CHANGE)$',100)
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)
      CALL LEGLIN
      CALL DASH
      CALL CURVE (DRMR,DPTTR,324,0)
      CTTR = FTMR(I)*550.0 / (DEN*ATR*RVMR*L*VTTR**2.0)
      TLTR = 1.0 - SQRT(2.0*CTTR) / IBTR
      PITR(I) = PTMR(I)*VITR / (L*RVMR*TLTR)
      POTR(I) = (SDTR*CDOTR*ATR*DEN*VTTR**3.0)* (1.0 + 4.3*ARTR**2.0)/
     * (550.0 * 8.0)
      PTTR(I) = PITR(I) + POTR(I)
      PTAC(I) = PTMR(I) + PTTR(I)
      RETURN
      END
C*****************************************************************************
C
C     SUBROUTINE TO CALCULATE CONSTANTS
C
C*****************************************************************************
C*****************************************************************************
      SUBROUTINE CONST
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS
C-----------------------------------------------------------------------------
      PIE = 3.141593
      VF = VF * 1.68889
      VV = VV / 60.0
      ATR = PIE * RTR**2.0
      VTTR = RVTR * RTR
      ARTR = VF / (RVTR*RTR)
      SDTR = IBTR*CTR / (PIE*RTR)
      HD = (SKDHT+RTHT) / (RMR(I)*2.0)
      IF(HD .GT. 1.6) GO TO 10
      GE = -0.1276*HD**4 + 0.708*HD**3 - 1.4569*HD**2 + 1.3432*HD +
     *  0.5147
      GO TO 11
10    GE = 1.0
11    CONTINUE
      RETURN
      END
C============================================================================
C=============                                     ==========================
C===================          SUB-GROUP C          ==========================
C=============            GRAPHS SUBROUTINES         ==========================
C===============                                   ==========================
C============================================================================
C*****************************************************************************
```

```
      END
C***********************************************************************
C
C      SUBROUTINE TO CALCULATE POWER REQUIREMENTS FOR MAIN ROTOR
C
C***********************************************************************
C***********************************************************************
      SUBROUTINE POWMR
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SDTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1
      COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
     * PCTR(400),PTMR(400),PTTR(400),PTAC(400)
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS
C-----------------------------------------------------------------------
      CTMR = W/(DEN*AMR*VTMR**2.0)
      TLMR = 1.0 - (SQRT(2.0*CTMR) / FLOAT(IBMR))
      PIMR(I) = W*VIMR*GE / (TLMR*550.0)
      POMR(I) = (SDMR*CDOMR*DEN*AMR*VTMR**3.0) * (1.0 + 4.3*ARMR**2.0)/
     * (550.0 * 8.0)
      PPMR(I) = 0.5*DEN * (VF**3.0*EFPAF + VV**3.0*EFPAV) / 550.0
      PCMR(I) = W*VV / 550.0
      PTMR(I) = PIMR(I) + POMR(I) + PPMR(I) + PCMR(I)
      RETURN
      END
C***********************************************************************
C
C      SUBROUTINE TO CALCULATE POWER REQUIREMENTS FOR TAIL ROTOR
C         AND POWER FOR TOTAL AIRCRAFT.
C
C***********************************************************************
C***********************************************************************
      SUBROUTINE POWTR
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SDTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1
      COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
     * PCTR(400),PTMR(400),PTTR(400),PTAC(400)
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS
C-----------------------------------------------------------------------
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      CELTA = PRESS1/2116.22
      RETLRN
      ENC
C*************************************************************************
C
C    SUBROUTINE TO CALCULATE INDUCED VELOCITY FOR MAIN ROTOR
C
C*************************************************************************
C*************************************************************************
      SUEROLTINE VELMR
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SCTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,CIFF,SFCM,SFCN,SFCC,SHPM,SHFN,SHFC,CMR1,RVMR1
C-------------------------------------------------------------------------
      VIHMR = SQRT(W/(2.0*DEN*AMR))
      VITMR = SQRT(-(VF**2./2.0) + SCRT((VF**2./2.0)**2.0 + VIHMR**4))
      VIMR = VITMR
      IF (VF .NE. 0.0 .OR. VV .EC. 0.0) GC TC 10
      VIVMR = 0.5*(-VV + SQRT(VV + 4*VIHMR))
      VIMR = VIVMR
 10   CONTINLE
      RETURN
      ENC
C*************************************************************************
C
C     SUBROLTINE TO CALCLLATE INDUCED VELCCITY FOR TAIL ROTOR
C
C*************************************************************************
C*************************************************************************
      SUEROUTINE VELTR
      IMFLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADILS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,CENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,CIFF,SFCM,SFCN,SFCC,SHPM,SHFN,SHFC,CMR1,RVMR1
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS
       CCMMCN /B/ PIMR(400),PCMR(400),PPMR(400),PCMR(400),PITR(400),
     * POTR(400),PTMR(400),PTTR(400),PTAC(400)
C-------------------------------------------------------------------------
      VIHTR = SQRT(PTMR(I)*550.0/(2.0*DEN*ATR*RVMR*L))
      VITTR = SQRT(-(VF**2./2.)+SQRT((VF**2./2.)**2.+VIHTR**4.))
      VITR = VITTR
      RETLRN
```

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               SEVALT(I) = DA                                            PER09610
               GO TO 1520                                                PER09620
1500         CONTINUE                                                    PER09630
1520      CONTINUE                                                       PER09640
          SEVALT(I) = SEVALT(I) - 0.5                                    PER09650
      IF(SEVALT(I) .LT. MIN) MIN = SEVALT(I)                             PER09660
      IF(SEVALT(I) .GT. MAX) MAX = SEVALT(I)                             PER09670
1540  CONTINUE                                                           PER09680
C------------------------------------------------------------------------PER09690
      MAXY = -500.0                                                      PER09700
      MINY = 500.0                                                       PER09710
      DO 1700 I = 1,324                                                  PER09720
         DSEVAL(I) = ((SEVALT(I) - SEVALT(163)) / SEVALT(163)) * 100.0   PER09730
         DRMR(I) = ((RMR(I) - RMR(163)) / RMR(163)) * 100.0              PER09740
         IF(DSEVAL(I) .GT. MAXY) MAXY = DSEVAL(I)                        PER09750
         IF(DSEVAL(I) .LT. MINY) MINY = DSEVAL(I)                        PER09760
1700  CONTINUE                                                           PER09770
      CALL GRAF6                                                         PER09780
      RETURN                                                             PER09790
      END                                                                PER09800
C========================================================================PER09810
C=============                                 ==========================PER09820
C=====================       SUB-GROUP A     ============================PER09830
C==============      GENERAL USE SUBROUTINES      =======================PER09840
C================                            ============================PER09850
C========================================================================PER09860
C*********************************************************************** PER09870
C                                                                        PER09880
C     SUBROUTINE TO CALCULATE DENSITY ALTITUDE                           PER09890
C                                                                        PER09900
C*********************************************************************** PER09910
C*********************************************************************** PER09920
      SUBROUTINE RHO                                                     PER09930
      IMPLICIT REAL (A-H,L-Z)                                            PER09940
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,        PER09950
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,     PER09960
     * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,     PER09970
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3, PER09980
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1               PER09990
C------------------------------------------------------------------------PER10000
      IF (TEMP .EQ. 0.0 .OR. PA .EQ. 0.0 ) GO TO 10                      PER10010
      H = (1.0-(PA*6.875E-06))**5.2561 / ((TEMP-32.0)*0.5555+273.16)     PER10020
      DA = (1.0-(H*288.16)**0.23496) / 6.875E-06                         PER10030
10    DEN = 0.0023769*(1.0-6.875E-06*DA)**4.2561                         PER10040
      TEMP1 = 518.688*(1.0-6.875E-06*DA)                                 PER10050
      PRESS1 = 2116.22*(1.0-6.875E-06*DA)**5.2561                        PER10060
      DEN1 = DENSSL*(1.0-6.875E-06*DA)**4.2561                           PER10070
      THETA = TEMP1/518.688                                              PER10080
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         VF = VFF                                                       PERO9130
         DA = FLOAT(J)*1000.0                                           PERO9140
         CALL RHO                                                       PERO9150
         VV = 100.0                                                     PERO9160
         CALL CONST                                                     PERO9170
         ARMR = VF / (RVMR*RMR(I))                                      PERO9180
         CALL VELMR                                                     PERO9190
         CALL POWMR                                                     PERO9200
         CALL VELTR                                                     PERO9210
         CALL POWTR                                                     PERO9220
         FCWAA = PTAVAL*DELTA*SQRT(THETA)                               PERO9230
         IF (PTAC(I) .LT. POWAA) GO TO 1420                             PERO9240
            SEVALT(I) = DA                                              PERO9250
            GO TO 1440                                                  PERO9260
 1420    CONTINUE                                                       PERO9270
 1440 CONTINUE                                                          PERO9280
      SEV = SEVALT(I) - 1000.0                                          PERO9290
      DO 1460 J = 1,20                                                  PERO9300
         VF = VFF                                                       PERO9310
         DA = FLOAT(J)*50.0 + SEV                                       PERO9320
         CALL RHO                                                       PERO9330
         VV = 100.0                                                     PERO9340
         CALL CONST                                                     PERO9350
         ARMR = VF / (RVMR*RMR(I))                                      PERO9360
         CALL VELMR                                                     PERO9370
         CALL POWMR                                                     PERO9380
         CALL VELTR                                                     PERO9390
         CALL POWTR                                                     PERO9400
         FCWAA = PTAVAL*DELTA*SQRT(THETA)                               PERO9410
         IF (PTAC(I) .LT. POWAA) GO TO 1460                             PERO9420
            SEVALT(I) = DA                                              PERO9430
            GO TO 1480                                                  PERO9440
 1460    CONTINUE                                                       PERO9450
 1480 CONTINUE                                                          PERO9460
      SEV = SEVALT(I) - 50.0                                            PERO9470
      DO 1500 J = 1,100                                                 PERO9480
         VF = VFF                                                       PERO9490
         DA = FLOAT(J)*0.5 + SEV                                        PERO9500
         CALL RHO                                                       PERO9510
         VV = 100.0                                                     PERO9520
         CALL CONST                                                     PERO9530
         ARMR = VF / (RVMR*RMR(I))                                      PERO9540
         CALL VELMR                                                     PERO9550
         CALL POWMR                                                     PERO9560
         CALL VELTR                                                     PERO9570
         CALL POWTR                                                     PERO9580
         FCWAA = PTAVAL*DELTA*SQRT(THETA)                               PERO9590
         IF (PTAC(I) .LT. POWAA) GO TO 1500                             PERO9600
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C*********************************************************************** PER08650
      SUBROUTINE CEIL                                                   PER08660
      IMPLICIT REAL (A-H,L-Z)                                           PER08670
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,       PER08680
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,    PER08690
     * SDTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,    PER08700
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,PER08710
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHFC,CMR1,RVMR1,RRMR         PER08720
      COMMON /B/ PIMR(400),POMR(400 ),PPMR(400),PCMR(400 ),PITR(400),   PER08730
     * POTR(400),PTMR(400),PTTR(400),PTAC(400)                          PER08740
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,     PER08750
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)   PER08760
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),         PER08770
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),      PER08780
     * DFMERT(400),VFEND(400),DVFEND(400)                               PER08790
      COMMON /Z/ VFEND1(400),VFEND2(400),VFEND3(400),VFEND4(400)        PER08800
C-----------------------------------------------------------------------PER08810
      SKCHT = 2500.0                                                    PER08820
      MIN = 30000.0                                                     PER08830
      MAX = 0.0                                                         PER08840
      PA = 0.0                                                          PER08850
      TEMP = 0.0                                                        PER08860
      IF(IENG .EQ. 1) PTAVAL = (FLOAT(IENG)*SHPN - 10.0) * 0.97         PER08870
      IF(IENG .EQ. 2) PTAVAL = (FLOAT(IENG)*SHPN - 10.0)*0.9*0.97       PER08880
      IF(IENG .EQ. 3) PTAVAL = (FLOAT(IENG)*SHPN - 10.0)*0.9*0.94       PER08890
      DO 1540 I = 1,324                                                 PER08900
         AMR = RMR(I)**2.0*PIE                                          PER08910
         IF(K .NE.1) GO TO 1408                                         PER08920
              VFF = VFEND1(I)                                           PER08930
              VTMR = RVMR1*RMR(I)                                       PER08940
              SDMR = IBMR*CMR1 / (PIE*RMR(I))                           PER08950
1408     IF(K .NE. 2) GO TO 1412                                        PER08960
              VFF = VFEND2(I)                                           PER08970
              RVMR = VTMR2/RMR(I)                                       PER08980
              VTMR = RVMR*RMR(I)                                        PER08990
              SDMR = IBMR*CMR1 / (PIE*RMR(I))                           PER09000
1412     IF(K .NE. 3) GO TO 1414                                        PER09010
              VFF = VFEND3(I)                                           PER09020
              CMR = SDMR3*PIE*RMR(I)/IBMR                               PER09030
              SDMR = IBMR*CMR / (PIE*RMR(I))                            PER09040
              VTMR = RVMR1*RMR(I)                                       PER09050
1414     IF(K .NE. 4) GO TO 1416                                        PER09060
              CMR = SDMR3*PIE*RMR(I)/IBMR                               PER09070
              SDMR = IBMR*CMR / (PIE*RMR(I))                            PER09080
              RVMR = VTMR2/RMR(I)                                       PER09090
              VTMR = RVMR*RMR(I)                                        PER09100
              VFF = VFEND4(I)                                           PER09110
1416     DO 1420 J = 1,30                                               PER09120
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         CO 1160 J = 1,20                                                PER08170
             CA = FLOAT(J)*50.0 + HUV                                    PER08180
             CALL RHO                                                    PER08190
             CALL CONST                                                  PER08200
             CALL VELMR                                                  PER08210
             CALL POWMR                                                  PER08220
             CALL VELTR                                                  PER08230
             CALL POWTR                                                  PER08240
             FCWAA = PTAVAL*CELTA*SQRT(THETA)                            PER08250
             IF (PTAC(I) .LT. POWAA) GCTC 1160                           PER08260
                HOVALT(I) = DA                                           PER08270
                GC TC 1180                                               PER08280
1160         CCNTINUE                                                    PER08290
1180     CONTINUE                                                        PER08300
         HOV = HOVALT(I) - 50.0                                          PER08310
         CO 12C0 J = 1,100                                               PER08320
             CA = FLOAT(J)*0.5 + HOV                                     PER08330
             CALL RHO                                                    PER08340
             CALL CONST                                                  PER08350
             CALL VELMR                                                  PER08360
             CALL POWMR                                                  PER08370
             CALL VELTR                                                  PER08380
             CALL POWTR                                                  PER08390
             POWAA = PTAVAL*DELTA*SQRT(THETA)                            PER08400
             IF (PTAC(I) .LT. POWAA) GOTC 120C                           PER08410
                HCVALT(I) = DA-0.5                                       PER08420
                GC TO 1220                                               PER08430
1200         CCNTINUE                                                    PER08440
1220     CONTINLE                                                        PER08450
      IF(HOVALT(I) .LT. MIN) MIN = HCVALT(I)                             PER08460
      IF(HOVALT(I) .GT. MAX) MAX = HCVALT(I)                             PER08470
1240  CONTINLE                                                           PER08480
C----------------------------------------------------------------------- PER08490
      MAXY = -500.0                                                      PER08500
      MINY = 5C0.C                                                       PER08510
      CO 1400 I = 1,324                                                  PER08520
          DHOVAL(I) = ((HCVALT(I) - HOVALT(163)) / HOVALT(163)) * 100.0  PER08530
          IF(CHOVAL(I) .GT. MAXY) MAXY = DHOVAL(I)                       PER08540
          IF(CHOVAL(I) .LT. MINY) MINY = CHOVAL(I)                       PER08550
1400  CONTINLE                                                           PER08560
      CALL GRAF5                                                         PER08570
      RETURN                                                             PER08580
      END                                                                PER08590
C*********************************************************************** PER08600
C                                                                        PER08610
C     SUBRCUTINE TC CALCULATE THE MAXIMUM SERVICE CEILING                PER08620
C                                                                        PER08630
C*********************************************************************** PER08640
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      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),         PERO7690
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),      PERO7700
     * DFMERT(400),VFEND(400),DVFEND(400)                               PERO7710
C-----------------------------------------------------------------------PERO7720
      VF = 0.0                                                          PERO7730
      VV = 0.0                                                          PERO7740
      SKCHT = 10.0                                                      PERO7750
      MIN = 30000.0                                                     PERO7760
      MAX = 0.0                                                         PERO7770
      PA = 0.0                                                          PERO7780
      TEMP = 0.0                                                        PERO7790
      IF(IENG .EQ. 1) PTAVAL = (FLOAT(IENG)*SHPN - 10.0) * 0.97         PERO7800
      IF(IENG .EQ. 2) PTAVAL = (FLOAT(IENG)*SHPN - 10.0)*0.9*0.97       PERO7810
      IF(IENG .EQ. 3) PTAVAL = (FLOAT(IENG)*SHPN - 10.0)*0.9*0.94       PERO7820
      DO 1240 I = 1,324                                                 PERO7830
         AMR = RMR(I)**2.0*PIE                                          PERO7840
         IF(K .NE.1) GO TO 1108                                         PERO7850
              VTMR = RVMR1*RMR(I)                                       PERO7860
              SDMR = IBMR*CMR1 / (PIE*RMR(I))                           PERO7870
1108     IF(K .NE. 2) GO TO 1112                                        PERO7880
              RVMR = VTMR2/RMR(I)                                       PERO7890
              VTMR = RVMR*RMR(I)                                        PERO7900
              SDMR = IBMR*CMR1 / (PIE*RMR(I))                           PERO7910
1112     IF(K .NE. 3) GO TO 1114                                        PERO7920
              CMR = SDMR3*PIE*RMR(I)/IBMR                               PERO7930
              SDMR = IBMR*CMR / (PIE*RMR(I))                            PERO7940
              VTMR = RVMR1*RMR(I)                                       PERO7950
1114     IF(K .NE. 4) GO TO 1116                                        PERO7960
              CMR = SDMR3*PIE*RMR(I)/IBMR                               PERO7970
              SDMR = IBMR*CMR / (PIE*RMR(I))                            PERO7980
              RVMR = VTMR2/RMR(I)                                       PERO7990
              VTMR = RVMR*RMR(I)                                        PERO8000
1116     ARMR = VF / (RVMR*RMR(I))                                      PERO8010
         DO 1120 J = 1,30                                               PERO8020
              DA = FLOAT(J)*1000.0                                      PERO8030
              CALL RHO                                                  PERO8040
              CALL CONST                                                PERO8050
              CALL VELMR                                                PERO8060
              CALL POWMR                                                PERO8070
              CALL VELTR                                                PERO8080
              CALL POWTR                                                PERO8090
              POWAA = PTAVAL*DELTA*SQRT(THETA)                          PERO8100
              IF (PTAC(I) .LT. POWAA) GOTO 1120                         PERO8110
                 HOVALT(I) = DA                                         PERO8120
                 GO TO 1140                                             PERO8130
1120          CONTINUE                                                  PERO8140
1140     CONTINUE                                                       PERO8150
         HOV = HOVALT(I) - 1000.0                                       PERO8160
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```
            CALL POWMR
            CALL VELTR
            CALL POWTR
            CE = 550.0 * (PTAC(I)+PSHP) / VF
            WCE = W / DE
            IF (WDE .LT. RANMAX) GO TC 880
               RANMAX = WDE
               VFRAN(I) = VF/1.68885
               SHPRAN(I) = PTAC(I)
860         CCNTINUE
880      CONTINLE
      IF(VFRAN(I) .LT. MIN) MIN = VFRAN(I)
      IF(VFRAN(I) .GT. MAX) MAX = VFRAN(I)
900   CONTINLE
C---------------------------------------------------------------------
      MAXY = -500.0
      MINY = 5C0.C
      CO 1100 I = 1,324
          DVFRAN(I) = ((VFRAN(I) - VFRAN(163)) / VFRAN(163)) * 100.0
          IF(CVFRAN(I) .GT. MAXY) MAXY = CVFRAN(I)
          IF(CVFRAN(I) .LT. MINY) MINY = DVFRAN(I)
1100  CONTINLE
      IF ((MAXY - MINY) .GT. 0.5 ) GO TO 1102
      MAXY = MAXY + 1.5
      MINY = MINY - 1.5
      MIN = MIN - 0.50
      MAX = MAX + 0.50
1102  CONTINLE
      CALL GRAF4
      RETLRN
      ENC
C*********************************************************************
C
C     SUBROUTINE TO CALCULATE THE MAXIMUM HOVER CEILING (IGE)
C
C*********************************************************************
C*********************************************************************
      SUBROLTINE HOVER
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADILS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SCTR,SKCHT,TEMP,W,VF,VV,IBTR,IBMR,CENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,
     * VTMR2,CIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHFC,CMR1,RVMR1,RRMR
      CCMMCN /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
     * PCTR(4C0),PTMR(400),PTTR(400),PTAC(400)
      CCMMCN /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
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            VTMR = RVMR1*RMR(I)                                                     PERO06730
  734   IF(K .NE. 4) GO TO 736                                                      PERO06740
            CMR = SDMR3*PIE*RMR(I)/IBMR                                             PERO06750
            SDMR = IBMR*CMR / (PIE*RMR(I))                                          PERO06760
            RVMR = VTMR2/RMR(I)                                                     PERO06770
            VTMR = RVMR*RMR(I)                                                      PERO06780
  736   DO 740 J = 1,20                                                             PERO06790
            VF = FLOAT(J)*10.0                                                      PERO06800
            CALL CONST                                                              PERO06810
            ARMR = VF / (RVMR*RMR(I))                                               PERO06820
            CALL VELMR                                                              PERO06830
            CALL POWMR                                                              PERO06840
            CALL VELTR                                                              PERO06850
            CALL POWTR                                                              PERO06860
            DE = 550.0*(PTAC(I)+PSHP) / VF                                          PERO06870
            WDE = W / DE                                                            PERO06880
            IF (WDE .LE. RANMAX) GO TO 750                                          PERO06890
               RANMAX = WDE                                                         PERO06900
               VFRAN(I) = VF/1.68889                                                PERO06910
  740   CONTINUE                                                                    PERO06920
  750   CONTINUE                                                                    PERO06930
        VFF = VFRAN(I)                                                              PERO06940
        RANMAX = 0.0                                                                PERO06950
        DO 820 J = 1,20                                                             PERO06960
        VF = FLOAT(J)-1.0 + VFF                                                     PERO06970
            CALL CONST                                                              PERO06980
            ARMR = VF / (RVMR*RMR(I))                                               PERO06990
            CALL VELMR                                                              PERO07000
            CALL POWMR                                                              PERO07010
            CALL VELTR                                                              PERO07020
            CALL POWTR                                                              PERO07030
            DE = 550.0 * (PTAC(I)+PSHP) / VF                                        PERO07040
            IF(DE .EQ. 0.0) GO TO 780                                               PERO07050
            WDE = W / DE                                                            PERO07060
            GO TO 800                                                               PERO07070
  780       WDE = 0.0                                                               PERO07080
  800       IF (WDE .LT. RANMAX) GO TO 850                                          PERO07090
               RANMAX = WDE                                                         PERO07100
               VFRAN(I) = VF/1.68889                                                PERO07110
  820       CONTINUE                                                                PERO07120
  850   CONTINUE                                                                    PERO07130
        VFF = VFRAN(I)                                                              PERO07140
        RANMAX = 0.0                                                                PERO07150
        DO 860 J = 1,201                                                            PERO07160
        VF = (FLOAT(J-1)/100.0) + VFF                                               PERO07170
            CALL CONST                                                              PERO07180
            ARMR = VF / (RVMR*RMR(I))                                               PERO07190
            CALL VELMR                                                              PERO07200
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      RETURN                                                            PERO6250
      END                                                               PERO6260
C*********************************************************************** PERO6270
C                                                                       PERO6280
C     SUBROUTINE TO CALCULATE THE MAXIMUM RANGE VELOCITY                PERO6290
C                                                                       PERO6300
C*********************************************************************** PERO6310
C*********************************************************************** PERO6320
      SUBROUTINE RANGE                                                  PERO6330
      IMPLICIT REAL (A-H,L-Z)                                           PERO6340
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDOMR,CDOTR,CMR,CTMR,CTR,CTTR,       PERO6350
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADIUS,RTR,RTHT,RVMR,RVTR,SDMR,    PERO6360
     * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,DENSSL,PIE,PTMIN(400),VIMR,    PERO6370
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(400),VV1,VF1,IENG,SDMR3,PERO6380
     * VTMR2,DIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHPC,CMR1,RVMR1,RRMR         PERO6390
      COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),     PERO6400
     * PCTR(400),PTMR(400),PTTR(400),PTAC(400)                          PERO6410
      COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,     PERO6420
     * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)   PERO6430
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),         PERO6440
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),      PERO6450
     * DFMERT(400),VFEND(400),DVFEND(400)                               PERO6460
C---------------------------------------------------------------------- PERO6470
      MIN = 500.0                                                       PERO6480
      MAX = -500.0                                                      PERO6490
      PA = 4000.0                                                       PERO6500
      TEMP = 95.0                                                       PERO6510
      CALL RHC                                                          PERO6520
      WFM = SFCM*SHPM                                                   PERO6530
      WFN = SFCN*SHPN                                                   PERO6540
      WFC = SFCC*SHPC                                                   PERO6550
      BHAT = (WFM-WFC) / (SHPM-SHPC)                                    PERO6560
      AHAT = WFM - (BHAT*SHPM)                                          PERO6570
      PSHP = FLOAT(IENG)*AHAT*DELTA*SQRT(THETA)/BHAT                    PERO6580
      DO 900 I = 1,324                                                  PERO6590
         AMR = RMR(I)**2.0*PIE                                          PERO6600
         RANMAX = 0.0                                                   PERO6610
         VV = 0.0                                                       PERO6620
         IF(K .NE.1) GO TO 730                                          PERO6630
             VTMR = RVMR1*RMR(I)                                        PERO6640
             SDMR = IBMR*CMR1 / (PIE*RMR(I))                            PERO6650
730      IF(K .NE. 2) GO TO 732                                         PERO6660
             RVMR = VTMR2/RMR(I)                                        PERO6670
             VTMR = RVMR*RMR(I)                                         PERO6680
             SDMR = IBMR*CMR1 / (PIE*RMR(I))                            PERO6690
732      IF(K .NE. 3) GO TO 734                                         PERO6700
             CMR = SDMR3*PIE*RMR(I)/IBMR                                PERO6710
             SDMR = IBMR*CMR / (PIE*RMR(I))                             PERO6720
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492       IF(K .NE. 3) GO TO 494                                                    PERO5770
              VF = VFEND3(I)                                                        PERO5780
              CMR = SDMR3*PIE*RMR(I)/IBMR                                           PERO5790
              SCMR =  IBMR*CMR / (PIE*RMR(I))                                       PERO5800
              VTMR =  RVMR1*RMR(I)                                                  PERO5810
494       IF(K .NE. 4) GO TO 496                                                    PERO5820
              VF = VFEND4(I)                                                        PERO5830
              CMR = SDMR3*PIE*RMR(I)/IBMR                                           PERO5840
              SCMR =  IBMR*CMR / (PIE*RMR(I))                                       PERO5850
              RVMR =  VTMR2/RMR(I)                                                  PERO5860
              VTMR =  RVMR*RMR(I)                                                   PERO5870
496        DO 500 J = 1,80                                                          PERO5880
              VV = FLOAT(J)*100.0                                                   PERO5890
              CALL CONST                                                            PERO5900
              ARMR =  VF /  (RVMR*RMR(I))                                           PERO5910
              CALL VELMR                                                            PERO5920
              CALL POWMR                                                            PERO5930
              CALL VELTR                                                            PERO5940
              CALL POWTR                                                            PERO5950
              IF (PTAC(I)  .GT. PTAVAL) GO TO 520                                   PERO5960
              VF = VF/1.68889                                                       PERO5970
500        CONTINUE                                                                 PERO5980
520        RCMAXX = (VV*60.0) - 100.0                                               PERO5990
           VF = VF/1.68889                                                          PERO6000
           DO 540 J = 1,100                                                         PERO6010
              VV = FLOAT(J)*1.0 + RCMAXX                                            PERO6020
              CALL CONST                                                            PERO6030
              ARMR =  VF /  (RVMR*RMR(I))                                           PERO6040
              CALL VELMR                                                            PERO6050
158           CALL POWMR                                                            PERO6060
159           CALL VELTR                                                            PERO6070
              CALL POWTR                                                            PERO6080
              IF (PTAC(I)  .GT. PTAVAL) GO TC 560                                   PERO6090
              VF = VF/1.68889                                                       PERO6100
540        CONTINUE                                                                 PERO6110
560        RCMAX(I) =  (VV*60.0)-1.0                                                PERO6120
        IF(RCMAX(I) .LT. MIN) MIN = RCMAX(I)                                        PERO6130
        IF(RCMAX(I) .GT. MAX) MAX = RCMAX(I)                                        PERO6140
580     CONTINUE                                                                    PERO6150
C-------------------------------------------------------------------------------    PERO6160
        MAXY = -500.0                                                               PERO6170
        MINY = 500.0                                                                PERO6180
        DO 700 I = 1,324                                                            PERO6190
           DRCMAX(I) = ((RCMAX(I) - RCMAX(163)) / RCMAX(163)) * 100.0               PERO6200
           IF(DRCMAX(I) .GT. MAXY) MAXY = DRCMAX(I)                                 PERO6210
           IF(DRCMAX(I) .LT. MINY) MINY = DRCMAX(I)                                 PERO6220
700     CONTINUE                                                                    PERO6230
        CALL GRAF3                                                                  PERO6240
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480   CONTINLE
      IF(IANS .EQ. 3 .OR. IANS .EQ. 6) GO TO 482
      CALL GFAF2
482   CONTINLE
      RETURN
      ENC
C***********************************************************************
C
C       SLBROLTINE TO CALCLLATE THE MAXIMUM RATE OF CLIMB
C
C***********************************************************************
C***********************************************************************
      SUEROUTINE MAXRC
      IMPLICIT REAL (A-H,L-Z)
      COMMON /A/ AMR,ARMR,ARTR,ATR,CDCMR,CDOTR,CMR,CTMR,CTR,CTTR,
     * DA,DEN,EFPAF,EFPAV,GE,HD,L,PA,RADILS,RTR,RTHT,RVMR,RVTR,SDMR,
     * SDTR,SKDHT,TEMP,W,VF,VV,IBTR,IBMR,CENSSL,PIE,PTMIN(400),VIMR,
     * VITR,VTTR,VTMR,RANMAX,THETA,DELTA,SHPRAN(4CO),VV1,VF1,IENG,SDMR3,
     * VTMR2,CIFF,SFCM,SFCN,SFCC,SHPM,SHPN,SHFC,CMR1,RVMR1,RRMR
       COMMON /B/ PIMR(400),POMR(400),PPMR(400),PCMR(400),PITR(400),
     * PCTR(400),PTMR(400),PTTR(400),PTAC(400)
       CCMMCN /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,CMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS
      COMMON /W/ RCMAX(400),CRCMAX(400),VFRAN(400),DVFRAN(400),
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),
     * DFMERT(400),VFEND(400),DVFEND(400)
       CCMMCN /Z/ VFEND1(400),VFEND2(400),VFEND3(400),VFEND4(400)
C-----------------------------------------------------------------------
      PA = 0.C
      TEMP = C.0
      CA = 0.C
      IF(IENG .EQ. 1) PTAVAL = (FLOAT(IENG)*SHPM - 10.0) * 0.97
      IF(IENG .EQ. 2) PTAVAL = (FLOAT(IENG)*SHPM - 10.0)*0.9*0.97
      IF(IENG .EQ. 3) PTAVAL = (FLOAT(IENG)*SHPM - 10.0)*0.9*0.94
      CALL RFC
      MAX = C.C
      MIN = 8C00.0
      DO 580 I = 1,324
         AMR = RMR(I)**2.0*PIE
         IF(K .NE.1) GC TC 490
            VF = VFEND1(I)
            VTMR = RVMR1*RMR(I)
            SCMR = IBMR*CMR1 / (PIE*RMR(I))
490      IF(K .NE. 2) GO TO 492
            VF = VFEND2(I)
            RVMR = VTMR2/RMR(I)
            VTMR = RVMR*RMR(I)
            SCMR = IBMR*CMR1 / (PIE*RMR(I))
      CALL CHNDOT                                                       PER12010
      CALL CURVE (DRMR,DPTMR,322,0)                                     PER12020
      CALL CHNDSH                                                       PER12030
      CALL CURVE (DRMR,DPTAC,322,0)                                     PER12040
      MAXLIN=LINEST(TEXT,100,30)                                        PER12050
      CALL HEIGHT(0.1)                                                  PER12060
      CALL LINES('TAIL ROTOR POWER$',TEXT,1)                            PER12070
      CALL LINES('MAIN ROTOR POWER$',TEXT,2)                            PER12080
      CALL LINES('TOTAL POWER$',TEXT,3)                                 PER12090
      CALL LEGEND(TEXT,3,0.4,3.8)                                       PER12100
      CALL BLREC(0.3,3.7,1.95,0.75,1.2)                                 PER12110
      CALL RESET('HEIGHT')                                              PER12120
      CALL DOT                                                          PER12130
      CALL GRID (1,2)                                                   PER12140
      CALL ENDGR(0)                                                     PER12150
C-----------------------------------------------------------------------PER12160
      CALL PHYSOR(1.5,1.5)                                              PER12170
      CALL AREA2D (6.50,4.70)                                           PER12180
      CALL HEADIN ('POWER VERSUS RADIUS$',19,1.4,3)                     PER12190
      IF(K .NE. 1 ) GO TO 8                                             PER12200
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,     PER12210
     *             0.8,3)                                               PER12220
      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)  PER12230
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER12240
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER12250
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER12260
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                PER12270
    8 IF(K .NE. 2) GO TO 10                                             PER12280
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$', PER12290
     *          48,0.8,4)                                               PER12300
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)           PER12310
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER12320
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER12330
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER12340
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                PER12350
   10 IF( K .NE. 3) GO TO 12                                            PER12360
      CALL HEADIN ('SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',     PER12370
     *          44,0.8,4)                                               PER12380
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)      PER12390
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER12400
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER12410
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER12420
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                PER12430
   12 IF( K .NE. 4) GO TO 14                                            PER12440
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER12450
     *,51,0.8,4)                                                        PER12460
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY$',27,0.8,4)             PER12470
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER12480
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER12490
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER12500
      CALL MESSAG('CASE 4$',100,8.7,6.0)                                PER12510
 14   CALL ENDPL(0)                                                     PER12520
      RETURN                                                            PER12530
      END                                                               PER12540
C*********************************************************************  PER12550
C                                                                       PER12560
C     SUBROUTINE  TO CREATE GRAPH OF POWER (INDUCED,PROFILE, ETC.)      PER12570
C         VS RADIUS.                                                    PER12580
C                                                                       PER12590
C*********************************************************************  PER12600
C*********************************************************************  PER12610
      SUBROUTINE GRAFIC                                                 PER12620
      IMPLICIT REAL (A-H,L-Z)                                           PER12630
       COMMON /B/ PIMR(400),POMR(400 ),PPMR(400),PCMR(400),PITR(400),   PER12640
     * POTR(400),PTMR(400),PTTR(400),PTAC(400)                          PER12650
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,    PER12660
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS, TEXT(200)  PER12670
       COMMON /Y/DPIMR(400),DPOMR(400),DPPMR(400),DPCMR(400),DPTMR(400),PER12680
     * DPITR(400),DPOTR(400),DPTAC(400)                                 PER12690
      CALL COMPRS                                                       PER12700
      CALL PAGE (11.0,8.5)                                              PER12710
      CALL PHYSOR(1.5,1.5)                                              PER12720
      CALL AREA2D (2.50,4.50)                                           PER12730
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)                     PER12740
      CALL YNAME ('POWER REQUIRED (SHP)$',100)                          PER12750
      CALL GRAF (MINZ,'SCALE',MAXZ,0.0,'SCALE',MAXA)                    PER12760
      CALL LEGLIN                                                       PER12770
      CALL CURVE (RMR,PIMR,324,0)                                       PER12780
      CALL DASH                                                         PER12790
      CALL CURVE (RMR,POMR,324,0)                                       PER12800
      CALL CHNDOT                                                       PER12810
      CALL CURVE (RMR,PPMR,324,0)                                       PER12820
      CALL CHNDSH                                                       PER12830
      CALL CURVE (RMR,PITR,324,0)                                       PER12840
      CALL DOT                                                          PER12850
      CALL CURVE (RMR,POTR,324,0)                                       PER12860
      IF (VV .LE. 0.0) GO TO 20                                         PER12870
      CALL CURVE (RMR,PCMR,324,0)                                       PER12880
 20   MAXLIN=LINEST(TEXT,100,30)                                        PER12890
      CALL HEIGHT(0.1)                                                  PER12900
      CALL LINES('INDUCED POWER (MR)$',TEXT,1)                          PER12910
      CALL LINES('PROFILE POWER (MR)$',TEXT,2)                          PER12920
      CALL LINES('PARASITE POWER (MR)$',TEXT,3)                         PER12930
      CALL LINES('INDUCED POWER (TR)$',TEXT,4)                          PER12940
      CALL LINES('PROFILE POWER (TR)$',TEXT,5)                          PER12950
      CALL LEGEND(TEXT,5,0.4,3.50)                                      PER12960
      CALL BLREC(0.3,3.42,2.15,1.00,1.1)                               PER12970
      CALL RESET('HEIGHT')                                             PER12980
      CALL DOT                                                         PER12990
      CALL GRID (1,2)                                                  PER13000
      CALL ENDGR(0)                                                    PER13010
C-----------------------------------------------------------------------PER13020
      CALL PHYSOR(5.5,1.5)                                             PER13030
      CALL AREA2D (2.50,4.50)                                          PER13040
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)              PER13050
      CALL YNAME ('POWER REQUIRED (% CHANGE)$',100)                    PER13060
      CALL GRAF (DMIN,'SCALE',DMAX,MINX,'SCALE',MAXX)                  PER13070
      CALL LEGLIN                                                      PER13080
      CALL CURVE (DRMR,DPIMR,324,0)                                    PER13090
      CALL DASH                                                        PER13100
      CALL CURVE (DRMR,DPOMR,324,0)                                    PER13110
      CALL CHNDOT                                                      PER13120
      CALL CURVE (DRMR,DPPMR,324,0)                                    PER13130
      CALL CHNDSH                                                      PER13140
      CALL CURVE (DRMR,DPITR,324,0)                                    PER13150
      CALL DOT                                                         PER13160
      CALL CURVE (DRMR,DPCTR,324,0)                                    PER13170
      IF (VV .LE. 0.0) GO TO 22                                        PER13180
      CALL CURVE (DRMR,DPCMR,322,0)                                    PER13190
22    MAXLIN=LINEST(TEXT,100,30)                                       PER13200
      CALL HEIGHT(0.1)                                                 PER13210
      CALL LINES('INDUCED POWER (MR)$',TEXT,1)                         PER13220
      CALL LINES('PROFILE POWER (MR)$',TEXT,2)                         PER13230
      CALL LINES('PARASITE POWER (MR)$',TEXT,3)                        PER13240
      CALL LINES('INDUCED POWER (TR)$',TEXT,4)                         PER13250
      CALL LINES('PROFILE POWER (TR)$',TEXT,5)                         PER13260
      CALL LEGEND(TEXT,5,0.4,3.50)                                     PER13270
      CALL BLREC(0.3,3.42,2.2,1.00,1.2)                                PER13280
      CALL RESET('HEIGHT')                                             PER13290
      CALL DOT                                                         PER13300
      CALL GRID (1,2)                                                  PER13310
      CALL ENDGR(0)                                                    PER13320
C-----------------------------------------------------------------------PER13330
      CALL PHYSOR(1.5,1.5)                                             PER13340
      CALL AREA2D (6.50,4.70)                                          PER13350
      CALL HEADIN ('POWER VERSUS RADIUS$',19,1.4,3)                    PER13360
      IF(K .NE. 1 ) GO TO 8                                            PER13370
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,    PER13380
     *             0.8,3)                                              PER13390
      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIOS$',38,0.8,4)PER13400
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8, 4)            PER13410
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                          PER13420
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                           PER13430
      CALL MESSAG('CASE 1$',100,8.7,6.0)                               PER13440
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8     IF(K .NE. 2) GO TO 10                                                    PER13450
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$',        PER13460
     *      48,0.8,4)                                                          PER13470
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)                  PER13480
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                    PER13490
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                                  PER13500
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                   PER13510
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                       PER13520
10    IF( K .NE. 3) GO TO 12                                                   PER13530
      CALL HEADIN (' SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',           PER13540
     *      44,0.8,4)                                                          PER13550
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)             PER13560
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                    PER13570
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                                  PER13580
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                   PER13590
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                       PER13600
12    IF( K .NE. 4) GO TO 14                                                   PER13610
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER13620
     *,51,0.8,4)                                                               PER13630
      CALL HEADIN (' CHORD & ROTATIONAL VELOCITY$',27,0.8,4)                   PER13640
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                    PER13650
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                                  PER13660
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                   PER13670
      CALL MESSAG('CASE 4$',100,8.7,6.0)                                       PER13680
14    CALL ENDPL(0)                                                            PER13690
      RETURN                                                                   PER13700
      END                                                                      PER13710
C********************************************************************           PER13720
C                                                                              PER13730
C    SUBROUTINE TO CREATE GRAPH FOR ENDURANCE VELOCITY VS RADIUS               PER13740
C                                                                              PER13750
C********************************************************************           PER13760
C********************************************************************           PER13770
      SUBROUTINE GRAF2                                                         PER13780
      IMPLICIT REAL (A-H,L-Z)                                                  PER13790
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,           PER13800
     * MAXZ,CMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)          PER13810
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),                PER13820
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),             PER13830
     * DFMERT(400),VFEND(400),DVFEND(400)                                      PER13840
      CALL COMPRS                                                              PER13850
      CALL PAGE (11.0,8.5)                                                     PER13860
      CALL PHYSOR(1.5,1.5)                                                     PER13870
      CALL AREA2D (2.50,4.50)                                                  PER13880
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)                            PER13890
      CALL YNAME ('ENDURANCE VELOCITY (KNOTS)$',100)                           PER13900
      CALL GRAF (MINZ,'SCALE',MAXZ,MIN,'SCALE',MAX)                            PER13910
      CALL CURVE (RMR,VFEND,324,0)                                             PER13920
      CALL DOT                                                          PER13930
      CALL GRID (1,2)                                                   PER13940
      CALL RESET('DOT')                                                 PER13950
      CALL ENDGR(0)                                                     PER13960
C-----------------------------------------------------------------------PER13970
      CALL PHYSOR(5.5,1.5)                                              PER13980
      CALL AREA2D (2.50,4.50)                                           PER13990
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)               PER14000
      CALL YNAME ('ENDURANCE VELOCITY (% CHANGE)$',100)                 PER14010
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)                   PER14020
      CALL CURVE (DRMR,DVFEND,324,0)                                    PER14030
      CALL DOT                                                          PER14040
      CALL GRID (1,2)                                                   PER14050
      CALL ENDGR(0)                                                     PER14060
C---------------------------------------------------------------------- PER14070
      CALL PHYSOR(1.5,1.5)                                              PER14080
      CALL AREA2D (6.50,4.70)                                           PER14090
      CALL HEADIN ('ENDURANCE VELOCITY VERSUS RADIUS$',32,1.4,3)        PER14100
      IF(K .NE. 1 ) GO TO 8                                             PER14110
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,     PER14120
     *            0.8,3)                                                PER14130
      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)  PER14140
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER14150
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER14160
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER14170
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                PER14180
    8 IF(K .NE. 2) GO TO 10                                             PER14190
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$', PER14200
     *      48,0.8,4)                                                   PER14210
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)           PER14220
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER14230
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER14240
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER14250
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                PER14260
   10 IF( K .NE. 3) GO TO 12                                            PER14270
      CALL HEADIN (' SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',    PER14280
     *      44,0.8,4)                                                   PER14290
      CALL HEADIN (' CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)     PER14300
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER14310
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER14320
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER14330
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                PER14340
   12 IF( K .NE. 4) GO TO 14                                            PER14350
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER14360
     *,51,0.8,4)                                                        PER14370
      CALL HEADIN (' CHORD & ROTATIONAL VELOCITY$',27,0.8,4)            PER14380
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER14390
      CALL MESSAG (' SPEC RMR =$',100,7.4,6.5)                          PER14400
      CALL REALNO (RMR(163),2,'ABUT','ABUT')
      CALL MESSAG('CASE 4$',100,8.7,6.0)
14    CALL ENDPL(0)
      RETURN
      END
C*****************************************************************
C
C     SUBROUTINE TO CREATE GRAPH FOR MAXIMUM RATE OF CLIMB VS RADIUS
C
C*****************************************************************
C******************************************************************
      SUBROUTINE GRAF3
      IMPLICIT REAL (A-H,L-Z)
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),
     * DFMERT(400),VFEND(400),DVFEND(400)
      CALL COMPRS
      CALL PAGE (11.0,8.5)
      CALL PHYSOR(1.5,1.5)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)
      CALL YNAME ('MAXIMUM RATE OF CLIMB (FT/SEC)$',100)
      CALL GRAF (MINZ,'SCALE',MAXZ,MIN,'SCALE',MAX)
      CALL CURVE (RMR,RCMAX,324,0)
      CALL DOT
      CALL GRID (1,2)
      CALL RESET('DOT')
      CALL ENDGR(0)
C-----------------------------------------------------------------
      CALL PHYSOR(5.5,1.50)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)
      CALL YNAME ('MAXIMUM RATE OF CLIMB (% CHANGE)$',100)
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)
      CALL CURVE (DRMR,DRCMAX,324,0)
      CALL DOT
      CALL GRID (1,2)
      CALL ENDGR(0)
C-----------------------------------------------------------------
      CALL PHYSOR(1.5,1.5)
      CALL AREA2D (6.50,4.70)
      CALL HEADIN ('MAXIMUM RATE OF CLIMB VERSUS RADIUS CHANGE$',
     *  42,1.4,4)
      IF(K .NE. 1 ) GO TO 8
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,
     *              0.8,3)
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      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)   PER14890
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)               PER14900
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER14910
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER14920
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                 PER14930
 8    IF(K .NE. 2) GO TO 10                                              PER14940
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$',  PER14950
     *      46,0.8,4)                                                    PER14960
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)            PER14970
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER14980
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER14990
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER15000
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                 PER15010
 10   IF( K .NE. 3) GO TO 12                                             PER15020
      CALL HEADIN ('SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',      PER15030
     *      44,0.8,4)                                                    PER15040
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)       PER15050
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER15060
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER15070
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER15080
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                 PER15090
 12   IF( K .NE. 4) GO TO 14                                             PER15100
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER15110
     *,51,0.8,4)                                                         PER15120
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY$',27,0.8,4)              PER15130
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER15140
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER15150
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER15160
      CALL MESSAG('CASE 4$',100,8.7,6.0)                                 PER15170
 14   CALL ENDPL(0)                                                      PER15180
      RETURN                                                             PER15190
      END                                                                PER15200
C*****************************************************************       PER15210
C                                                                        PER15220
C     SUBROUTINE TO CREATE GRAPH FOR MAXIMUM RANGE VELOCITY VS RADIUS    PER15230
C                                                                        PER15240
C*********************************************************************PER15250
C*********************************************************************PER15260
      SUBROUTINE GRAF4                                                   PER15270
      IMPLICIT REAL (A-H,L-Z)                                            PER15280
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,     PER15290
     * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)    PER15300
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),          PER15310
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),       PER15320
     * DFMERT(400),VFEND(400),DVFEND(400)                                PER15330
      CALL COMPRS                                                        PER15340
      CALL PAGE (11.0,8.5)                                               PER15350
      CALL PHYSOR(1.5,1.5)                                               PER15360
      CALL AREA2D (2.50,4.50)                                               PER15370
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)                         PER15380
      CALL YNAME ('MAXIMUM RANGE VELOCITY (KNOTS)$',100)                    PER15390
      CALL GRAF (MINZ,'SCALE',MAXZ,MIN,'SCALE',MAX)                         PER15400
      CALL CURVE (RMR,VFRAN,324,-1 )                                        PER15410
      CALL DOT                                                              PER15420
      CALL GRID (1,2)                                                       PER15430
      CALL RESET('DOT')                                                     PER15440
      CALL ENDGR(0)                                                         PER15450
C***********************************************************************PER15460
      CALL PHYSOR(5.5,1.5)                                                  PER15470
      CALL AREA2D (2.5,4.5)                                                 PER15480
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)                   PER15490
      CALL YNAME ('MAXIMUM RANGE VELOCITY (% CHANGE)$',100)                 PER15500
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)                       PER15510
      CALL CURVE (DRMR,DVFRAN,324,-1)                                       PER15520
      CALL DOT                                                              PER15530
      CALL GRID (1,2)                                                       PER15540
      CALL ENDGR(0)                                                         PER15550
C-----------------------------------------------------------------------    PER15560
      CALL PHYSOR(1.5,1.5)                                                  PER15570
      CALL AREA2D (6.50,4.70)                                               PER15580
      CALL HEADIN ('MAXIMUM RANGE VELOCITY VERSUS RADIUS CHANGE$',          PER15590
     *  43,1.4,4)                                                           PER15600
      IF(K .NE. 1 ) GO TO 8                                                 PER15610
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,         PER15620
     *            0.8,3)                                                    PER15630
      CALL HEADIN (' SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)     PER15640
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                  PER15650
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                               PER15660
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                PER15670
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                    PER15680
    8 IF(K .NE. 2) GO TO 10                                                 PER15690
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$',     PER15700
     *        48,0.8,4)                                                     PER15710
      CALL HEADIN (' SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)              PER15720
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                 PER15730
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                               PER15740
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                PER15750
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                    PER15760
   10 IF( K .NE. 3) GO TO 12                                                PER15770
      CALL HEADIN (' SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',        PER15780
     *        44,0.8,4)                                                     PER15790
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)          PER15800
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)                 PER15810
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                               PER15820
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                                PER15830
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                    PER15840
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12    IF( K .NE. 4) GC TC 14
      CALL HEADIN('SOLIDITY,ADVANCE RATIC & TIP VELOCITY HELD CONSTANT$'
     *,51,0.8,4)
      CALL HEADIN ('CHORD & ROTATIONAL VELCCITY$',27,0.8,4)
      CALL HEADIN ('ALLOWED TO VARY WITH RADILS$',27,0.8,4)
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)
      CALL REALNO (RMR(163),2,'ABUT','ABUT')
      CALL MESSAG('CASE 4$',100,8.7,6.0)
14    CALL ENDPL(0)
      RETURN
      END
C**********************************************************************
C
C     SUBROUTINE TO CREATE GRAPH FOR MAXIMUM HOVER CEILING
C
C***********************************************************************
C***********************************************************************
      SUBROUTINE GRAF5
      IMPLICIT REAL (A-H,L-Z)
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
     * MAXZ,DMIN,DMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),
     * DFMERT(400),VFEND(400),DVFEND(400)
      CALL COMPRS
      CALL PAGE (11.0,8.5)
      CALL PHYSOR(1.5,1.5)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)
      CALL YNAME ('MAXIMUM HOVER CEILING (FT)$',100)
      CALL GRAF (MINZ,'SCALE',MAXZ,MIN,'SCALE',MAX)
      CALL CURVE (RMR,HOVALT,324,0)
      CALL DOT
      CALL GRID (1,2)
      CALL RESET('DOT')
      CALL ENDGR(0)
C----------------------------------------------------------------------
      CALL PHYSOR(5.5,1.50)
      CALL AREA2D (2.50,4.50)
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)
      CALL YNAME ('MAXIMUM HOVER CEILING (% CHANGE)$',100)
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)
      CALL CURVE (DRMR,DHOVAL,324,0)
      CALL DOT
      CALL GRID (1,2)
      CALL ENDGR(0)
C----------------------------------------------------------------------
      CALL PHYSOR(1.5,1.5)
      CALL AREA2D (6.50,4.70)                                           PER16330
      CALL HEADIN ('MAXIMUM HOVER CEILING (IGE) VERSUS RADIUS$',        PER16340
     *    41,1.2,4)                                                     PER16350
      IF(K .NE. 1 ) GO TO 8                                             PER16360
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,     PER16370
     *              0.8,3)                                              PER16380
      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)  PER16390
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8, 4)             PER16400
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER16410
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER16420
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                PER16430
8     IF(K .NE. 2) GO TO 10                                             PER16440
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$', PER16450
     *        48,0.8,4)                                                 PER16460
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)           PER16470
      CALL HEADIN (' ALLOWED TO VARY WITH RADIUS$',27,0.8,4)            PER16480
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER16490
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER16500
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                PER16510
10    IF( K .NE. 3) GO TO 12                                            PER16520
      CALL HEADIN ('SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',     PER16530
     *        44,0.8,4)                                                 PER16540
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)      PER16550
      CALL HEADIN (' ALLOWED TO VARY WITH RADIUS$',27,0.8,4)            PER16560
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER16570
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER16580
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                PER16590
12    IF( K .NE. 4) GO TO 14                                            PER16600
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER16610
     *,51,0.8,4)                                                        PER16620
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY$',27,0.8,4)             PER16630
      CALL HEADIN (' ALLOWED TO VARY WITH RADIUS$',27,0.8,4)            PER16640
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER16650
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER16660
      CALL MESSAG('CASE 4$',100,8.7,6.0)                                PER16670
14    CALL ENDPL(0)                                                     PER16680
      RETURN                                                            PER16690
      END                                                               PER16700
C*********************************************************************** PER16710
C                                                                       PER16720
C     SUBROUTINE TO CREATE GRAPH FOR MAXIMUM SERVIVE CEILING            PER16730
C                                                                       PER16740
C***********************************************************************PER16750
C***********************************************************************PER16760
      SUBROUTINE GRAF6                                                  PER16770
      IMPLICIT REAL (A-H,L-Z)                                           PER16780
       COMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,    PER16790
     * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS, TEXT(200)  PER16800
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      COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),          PER16810
     * HOVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),       PER16820
     * DFMERT(400),VFEND(400),DVFEND(400)                                PER16830
      CALL COMPRS                                                        PER16840
      CALL PAGE (11.0,8.5)                                               PER16850
      CALL PHYSOR(1.5,1.5)                                               PER16860
      CALL AREA2D (2.50,4.50)                                            PER16870
      CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',100)                      PER16880
      CALL YNAME ('MAXIMUM SERVICE CEILING (FT)$',100)                   PER16890
      CALL GRAF (MINZ,'SCALE',MAXZ,MIN,'SCALE',MAX)                      PER16900
      CALL CURVE (RMR,SEVALT,322,0)                                      PER16910
      CALL DOT                                                           PER16920
      CALL GRID (1,2)                                                    PER16930
      CALL RESET('DOT')                                                  PER16940
      CALL ENDGR(0)                                                      PER16950
C------------------------------------------------------------------------PER16960
      CALL PHYSOR(5.5,1.5)                                               PER16970
      CALL AREA2D (2.50,4.50)                                            PER16980
      CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)                PER16990
      CALL YNAME ('MAXIMUM SERVICE CEILING (% CHANGE)$',100)             PER17000
      CALL GRAF (DMIN,'SCALE',DMAX,MINY,'SCALE',MAXY)                    PER17010
      CALL CURVE (DRMR,DSEVAL,324,0)                                     PER17020
      CALL DOT                                                           PER17030
      CALL GRID (1,2)                                                    PER17040
      CALL ENDGR(0)                                                      PER17050
C------------------------------------------------------------------------PER17060
      CALL PHYSOR(1.5,1.5)                                               PER17070
      CALL AREA2D (6.50,4.70)                                            PER17080
      CALL HEADIN ('MAXIMUM SERVICE CEILING VERSUS RADIUS CHANGE$',      PER17090
     *    44,1.4,4)                                                      PER17100
      IF(K .NE. 1 ) GO TO 8                                              PER17110
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,      PER17120
     *          0.8,3)                                                   PER17130
      CALL HEADIN (' SOLIDITY, TIP VELOCITY & ADVANCE RATIOS',38,0.8,4)  PER17140
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)               PER17150
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER17160
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER17170
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                 PER17180
8     IF(K .NE. 2) GO TO 10                                              PER17190
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$',  PER17200
     *       48,0.8,4)                                                   PER17210
      CALL HEADIN (' SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)           PER17220
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER17230
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                            PER17240
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                             PER17250
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                 PER17260
10    IF( K .NE. 3) GO TO 12                                             PER17270
      CALL HEADIN ('SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',      PER17280
     *      44,C.8,4)
            CALL HEADIN ('CHORD,ADVANCE RATIO & TIF VELCCITY$',34,0.8,4)
            CALL HEACIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)
            CALL MESSAG (' SPEC RMR =$',100,7.4,6.5)
            CALL REALNO (RMR(163),2,'ABUT','ABUT')
            CALL MESSAG('CASE 3$',100,8.7,6.0)
   12       IF( K .NE. 4) GO TC 14
            CALL HEACIN('SOLIDITY,ADVANCE RATIC & TIP VELOCITY HELD CONSTANT$'
           *,51,0.8,4)
            CALL HEACIN ('CHORD & ROTATIONAL VELCCITY$',27,0.8,4)
            CALL HEACIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)
            CALL MESSAG (' SPEC RMR =$',100,7.4,6.5)
            CALL REALNO (RMR(163),2,'ABUT','ABUT')
            CALL MESSAG('CASE 4$',100,8.7,6.0)
   14       CALL ENDPL(0)
            RETURN
            ENC
C**************************************************************************
C
C           SUBROUTINE TO CREATE GRAPH OF FIGURE OF MERIT VS RADIUS
C
C**************************************************************************
C**************************************************************************
            SUBROUTINE GRAF1E
            IMPLICIT REAL (A-H,L-Z)
             CCMMON /C/ RMR(400),I,J,K,DRMR(400),MINX,MAXX,MINY,MAXY,MINZ,
           * MAXZ,CMIN,CMAX,MINB,MAXB,MINC,MAXC,MIN,MAX,MAXA,IANS,TEXT(200)
            COMMON /W/ RCMAX(400),DRCMAX(400),VFRAN(400),DVFRAN(400),
           * HCVALT(400),DHOVAL(400),SEVALT(400),DSEVAL(400),FMERT(400),
           * DFMERT(400),VFEND(400),DVFEND(400)
            CALL CCMPRS
            CALL PAGE (11.0,8.5)
            CALL PHYSOR(1.5,1.5)
            CALL AREA2D (2.50,4.50)
            CALL XNAME ('RADIUS OF MAIN ROTOR (FT)$',10C)
            CALL YNAME ('FIGUURE OF MERIT$',100)
            CALL GRAF (MINZ,'SCALE',MAXZ,MINB,'SCALE',MAXB)
            CALL CURVE (RMR,FMERT,324,0)
            CALL DCT
            CALL GRIC (1,2)
            CALL RESET('DOT')
            CALL ENDGR(0)
C-------------------------------------------------------------------------
            CALL PHYSOR(5.5,1.5)
            CALL AREA2D (2.50,4.50)
            CALL XNAME ('RADIUS OF MAIN ROTOR (% CHANGE)$',100)
            CALL YNAME ('FIGURE OF MERIT (% CHANGE)$',100)
            CALL GRAF (CMIN,'SCALE',DMAX,MINC,'SCALE',MAXC)
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      CALL CURVE (DRMR,DFMERT,324,0)                                    PER17770
      CALL DOT                                                          PER17780
      CALL GRID (1,2)                                                   PER17790
      CALL ENDGR(0)                                                     PER17800
C-----------------------------------------------------------------------PER17810
      CALL PHYSOR(1.5,1.5)                                              PER17820
      CALL AREA2D (6.50,4.70)                                           PER17830
      CALL HEADIN ('FIGURE OF MERIT VERSUS RADIUS CHANGE$',             PER17840
     *   36,1.4,4)                                                      PER17850
      IF(K .NE. 1 ) GO TO 8                                             PER17860
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY HELD CONSTANT$',41,     PER17870
     *            0.8,3)                                                PER17880
      CALL HEADIN ('SOLIDITY, TIP VELOCITY & ADVANCE RATIO$',38,0.8,4)  PER17890
      CALL HEADIN('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)              PER17900
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER17910
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER17920
      CALL MESSAG('CASE 1$',100,8.7,6.0)                                PER17930
8     IF(K .NE. 2) GO TO 10                                             PER17940
      CALL HEADIN ('CHORD,TIP VELOCITY & ADVANCE RATIO HELD CONSTANT$', PER17950
     *       48,0.8,4)                                                  PER17960
      CALL HEADIN ('SOLIDITY, ROTATIONAL VELOCITY$',29,0.8,4)           PER17970
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER17980
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER17990
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER18000
      CALL MESSAG('CASE 2$',100,8.7,6.0)                                PER18010
10    IF( K .NE. 3) GO TO 12                                            PER18020
      CALL HEADIN ('SOLIDITY & ROTATIONAL VELOCITY HELD CONSTANT$',     PER18030
     *       44,0.8,4)                                                  PER18040
      CALL HEADIN ('CHORD,ADVANCE RATIO & TIP VELOCITY$',34,0.8,4)      PER18050
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER18060
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER18070
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER18080
      CALL MESSAG('CASE 3$',100,8.7,6.0)                                PER18090
12    IF( K .NE. 4) GO TO 14                                            PER18100
      CALL HEADIN('SOLIDITY,ADVANCE RATIO & TIP VELOCITY HELD CONSTANT$'PER18110
     *,51,0.8,4)                                                        PER18120
      CALL HEADIN ('CHORD & ROTATIONAL VELOCITY$',27,0.8,4)             PER18130
      CALL HEADIN ('ALLOWED TO VARY WITH RADIUS$',27,0.8,4)             PER18140
      CALL MESSAG ('SPEC RMR =$',100,7.4,6.5)                           PER18150
      CALL REALNO (RMR(163),2,'ABUT','ABUT')                            PER18160
      CALL MESSAG('CASE 4$',100,8.7,6.0)                                PER18170
14    CALL ENDPL(0)                                                     PER18180
      RETURN                                                            PER18190
      END                                                               PER18200
C=======================================================================PER18210
C                                                                       PER18220
C   SUBROUTINE RDINT -- INTERACTIVELY READS AN INTEGER REPLY           =PER18230
C   INTO A FORTRAN PROGRAM.  IF THE USER INADVERTENLY ENTERS AN IMPROPER=PER18240
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C  DATA CHARACTER THE S/R ISSUES A WARNING ANC ALLOWS A RECOVERY.      =PER18250
C                                                                       PER18260
C======================================================================PER18270
      SUBROUTINE RDINT (IANS)                                           PER18280
      INTEGER CCUNT                                                     PER18290
C----------------------------------------------------------------------PER18300
      COUNT=C                                                           PER18310
10    CONTINLE                                                          PER18320
      COUNT=CCLNT+1                                                     PER18330
      IF (COLNT.LT.3) GO TO 20                                          PER18340
      WRITE (5,60)                                                      PER18350
      GO TO 5C                                                          PER18360
20    CONTINLE                                                          PER18370
      READ (5,*,END=40,ERR=40) IANS                                     PER18380
      IF (IANS) 40,40,30                                                PER18390
30    CONTINLE                                                          PER18400
      RETURN                                                            PER18410
40    REWIND 5                                                          PER18420
      WRITE (5,70)                                                      PER18430
      GO TO 1C                                                          PER18440
50    CONTINLE                                                          PER18450
      STOP                                                              PER18460
C----------------------------------------------------------------------PER18470
60    FORMAT (//,5X,49HPROGRAM TERMINATION - TWO IMPROPER DATA ENTRIES  PER18480
     1)                                                                 PER18490
70    FORMAT (1X,56HWARNING: IMPROPER DATA ENTRY   ENTER A POSITIVE INTEPER18500
     1GER.)                                                             PER18510
      END                                                               PER18520
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AD-A151 488 PRELIMINARY HELICOPTER DESIGN DECISION MAKING BASED ON 2/2
FLIGHT PERFORMANCE FACTORS(U) NAVAL POSTGRADUATE SCHOOL
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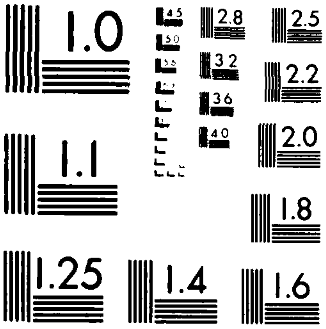

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2. Layton, Professor Donald M., Helicopter Performance, Naval Postgraduate School, Monterey California, 1983.

3. Layton, Professor Donald M., AE 4306 Design Design Manual, Naval Postgraduate School, Monterey California, 1983.

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